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TECHNIQUES OF ENDOBRONCHIAL ANAESTHESIA*†

By T. T. Currie

Department of Anaesthetics, Royal Melbourne Hospital

MAGILL, addressing the Royal Society of Medicine in 1936 said, "If thoracic surgery is likely to become routine in the general hospital, it is well that anaesthetists, who may be called upon to share the responsibility in this branch of work should benefit from the experience (mistakes included) of those who have been engaged regularly in this special type of anaesthesia for some years." The very specialized training which was required at that time by the thoracic anaesthetist has been lessened by the application of widely used general anaesthetic methods such as muscle relaxation, soda lime absorption and controlled respiration. Further, earlier diagnosis, chemotherapy and physiotherapy have so reduced the hazards confronting the thoracic anaesthetist that endotracheal controlled respiration techniques, no different from those employed for intra-abdominal surgery, can be used with a reasonable degree of safety for most cases. Because of this, there has been a tendency in general hospitals, in this country at least, to use endotracheal methods to the exclusion of more elaborate endobronchial techniques. This is unfortunate, partly because endobronchial methods must be constantly practised for them to be effective in the difficult case where such a technique may be essential, and also because of the incompleteness of registrar training when these methods are neglected.

It is the purpose of this paper to review the methods of endobronchial anaesthesia which are available and to illustrate these with recent cases in which in my opinion such a technique was essential.

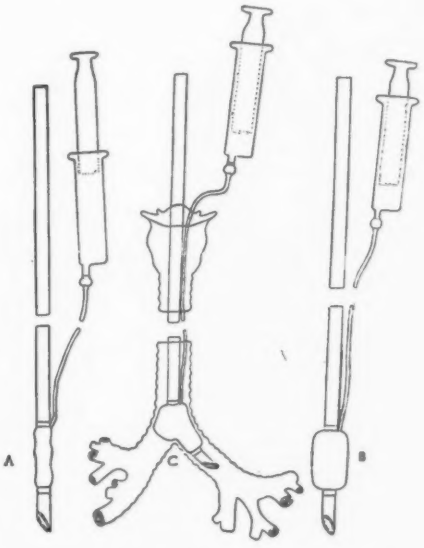

FIG. I. Gale and Waters' endobronchial tube. (By permission of *Journal of Thoracic Surgery*.)

Indications

Endobronchial techniques are used to control pus, blood or secretions arising from the lung and pleural cavity on the side of operation; to control the airway in large bronchopleural fistulae and to prevent tension-pneumothorax or tension-cyst in operations for emphysematous bullae and air cysts.

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Because of the small size of their air passages, blocking is precluded in children (under 13 years). In these young patients secretions may be controlled by Parry Brown's (Brown, 1948), or Overholt's prone position (Overholt and Langer, 1949), or Beecher's steep head down, lateral position (Beecher, 1940).

FIG. II. Magill's intubating bronchoscope and endobronchial tubes (right has wire coil).
(By permission of the publisher, "Principles of Thoracic Anaesthesia" — Mushin and Rendell Baker.)

HISTORICAL DEVELOPMENTS

One lung anaesthesia was first reported in 1931 by Waters and Gale of Madison, Wisconsin (Waters and Gale, 1932) (Fig. I). They passed a cuffed rubber and fabric endotracheal tube with a moulded lateral curve blindly into the required bronchus. The cuff was inflated at the bifurcation of the trachea, thus separating the non-operated from the operated lung. Although a criticism of this method has been that the cuff prevented the operated lung from collapsing, Gale and Waters in their article say, "The lung on the side of the operation is allowed to collapse and remain in a state of atelectasis throughout the procedure."

In 1934 Magill first mentioned his bronchial blocker (Fig. VI). The blocker consisted of a suction catheter with an inflatable balloon at the distal end. It was first tried by Magill in 1928 but proved to be a failure, because, owing to the poor anaesthetic methods of that time, coughing frequently caused the balloon to be expelled from the bronchus. With the quieter respirations provided by cyclopropane anaesthesia Magill showed that blockers could be used successfully.

In 1936 Magill introduced his cuffed endobronchial tubes (Fig. II) consisting of thin rubber covering a metal spiral. These were positioned under direct vision by means of an introducing bronchoscope. The technique of using a bronchoscope inside an anaesthetic tube had previously been described in 1932 by Coryllos in collaboration with McKesson (Fig. III). In 1936 Rovenstine published his recommendations for one lung anaesthesia in which he used an endobronchial tube with two cuffs, one in the trachea and the other in the main bronchus (Fig. IV). By alternating the inflation of the cuffs both lungs or only one could be inflated at will.

Thus by 1936, the principles underlying endobronchial technique had been established. Magill recognized three methods:

(i) endotracheal tube with intermittent suction of the diseased side;

(ii) endobronchial tube with cuff, to retain secretions in the diseased side, and

(iii) combination of blocker and endotracheal tube.

In addition, the other advances which had been made were the positioning of endobronchial tubes and blockers under direct vision

and the use of the tube with multiple cuffs to give the anaesthetist more versatility.

Many modifications of bronchial blockers have been reported. These include Archibald's (1935) which was inserted and directed by its coudé shape, X-ray being used to confirm its position. Crafoord described in 1938 his technique of packing the bronchus with gauze through a bronchoscope (Fig. V). The

One disadvantage of bronchus blocking is that a double manipulation is required to insert the blocker and then the anaesthetic tube. This was avoided in Magill's early pattern by passing the blocker through the lumen of the endotracheal tube. However, this restricts the airway and, generally speaking, where a completely closed circuit is not required, the blocker is better placed alongside the anaesthetic tube. In order to overcome this prob-

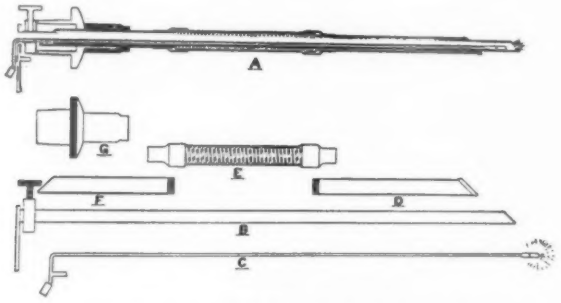

FIG. III. Carylios' and McKesson's intubating equipment.
(By permission of *Anaesthesia and Analgesia.*)

main disadvantage of this method was that it prevented the lung on the side of the operation from collapsing. In 1943 Halton described a bronchial occluder without suction aid. Thompson (Rusby and Thompson, 1943), a surgeon of the London Chest Hospital, used a blocker (Fig. VI) which, like a Magill blocker, had two tubes, one for suction into which a stilette is temporarily passed for rigidity during insertion of the blocker, and a second for inflating the distal balloon, which, in the case of the Thompson blocker, is covered with nylon mesh to prevent overdistension and to lessen the likelihood of slipping. The Thompson blocker is bigger and is more robust than the Magill blocker. It takes an 11 mm. Negus bronchoscope to accommodate its passage and it can only be used for the larger bronchi. In 1947 Moody (Moody, Trent and Newton, 1947) described a blocker in which a row of beryllium hooks around the cuff held the blocker in place in the bronchus.

In 1952, Stephen of the Brompton Hospital suggested a technique for inserting a modified short cuffed Magill blocker into the upper lobe bronchus (Fig. VII).

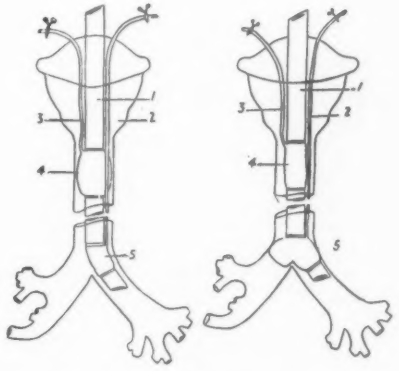

FIG. IV. Rovenstine's endobronchial tube with multiple cuffs.
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lem Stüertzbecher of Germany in 1955 (Fig. VIII) and Macintosh and Leatherdale of Oxford in the same year (Fig. IX) reported combined suction-blocker and anaesthetic tubes for blind insertion. At the same time Macintosh and Leatherdale described a left endobronchial tube with bronchial and tracheal cuffs and a small side tube for aspirat-

ing or inflating the right side. These "M-L" tubes are moulded so that they easily slide into the left side. The fairly rigid "M-L" blocker may annoy the surgeon as he dissects the left main bronchus. Although the "M-L" endobronchial tubes are easily and satisfactorily inserted in most cases, the largest blocker tends to be just too short in its tracheal section in large males where the inflation of the endobronchial cuff becomes too critical, varying from a leak around the blocker to complete obstruction of the right side with very little change of volume in the cuff. The "M-L" tubes find their greatest application in the desperately sick patient requiring one lung anaesthesia where speed of intubation and prevention of hypoxia during the positioning of the tube are essential.

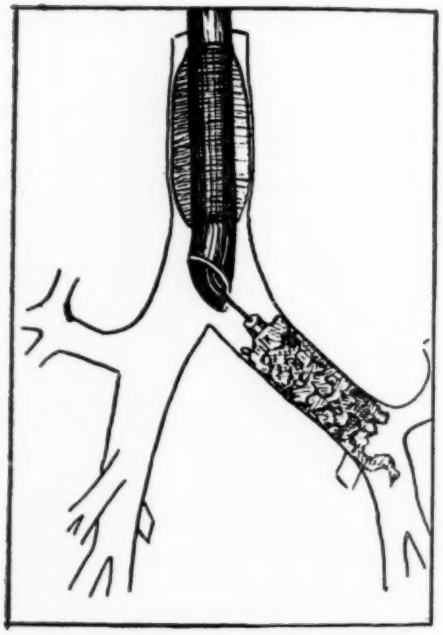

FIG. V. Crafoord's method of bronchial tamponage.
(By permission of *Proceedings of Royal Society of Medicine* — M. D. Noeworthy.)

Because of the tendency of endobronchial tubes with large cuffs to override the carina and prevent deflation of the operated lung, Machray of the Brompton Hospital (quoted by English, 1952) introduced a short cuffed endobronchial tube (Fig. X) which was intended only for intubating the left main bronchus.

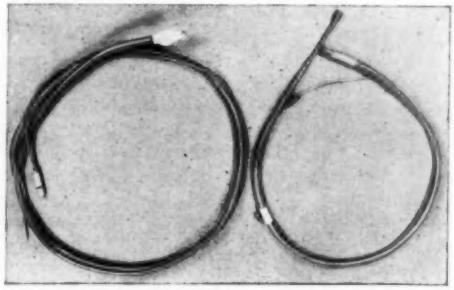

FIG. VI. Bronchial blockers. Left: Thompson's. Right: Magill's.

FIG. VII. Blocking technique for upper lobectomy.

In 1949 Carlens (Carlens, 1949; Bjork and Carlens, 1950, 1953) introduced his double lumen bronchospirometric catheter (Fig. XI) and later used it for thoracic anaesthesia. With practice, this large tube can be inserted atraumatically and, although the lumina of the catheter are smaller than that of a single lumen endobronchial tube, the difficulties with ventilation suggested by English and Mansfield of the Brompton Hospital have not been encountered in our unit. The Carlens catheter is particularly valuable in dealing with operations for ruptured emphysematous bullae and giant air-cysts. However, because it occupies a considerable part of the left main bronchus it is not recommended for left pneumonectomy or for plastic procedures involving the left main bronchus.

With the increase in the number of upper lobectomies and, in particular, the development of plastic procedures on the main bronchi, the need for endobronchial anaesthesia has become more definite, and this in turn has made necessary further attempts to

resolve the problems of right endobronchial intubation. Although blind intubation of the right main bronchus is commonly practised, using a Griffin's sucker (Griffin, 1949) as an introducer (frequently with a large cuffed Magill endotracheal tube), consideration of normal bronchial anatomy shows that such a procedure is unreliable. The position of origin of the right upper lobe bronchus, averaging 2 cm. from the carina, leaves so little room for error that a blind method of placing a cuff proximal to this orifice seems unwise. The probabilities are that the right upper lobe orifice will be partially or completely obstructed, or that the anaesthetic tube cuff will override the carina and prevent deflation of the lung on the side of operation.

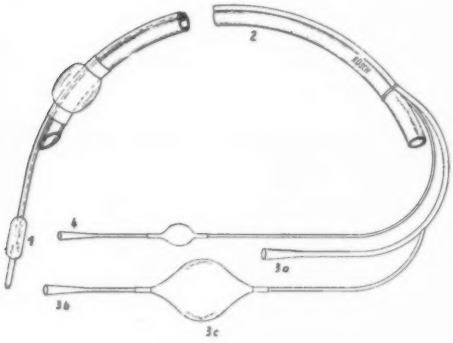

FIG. VIII. Stuertzbecher's combined bronchus blocker and endotracheal tube.
(By permission of *Anesthesiology*.)

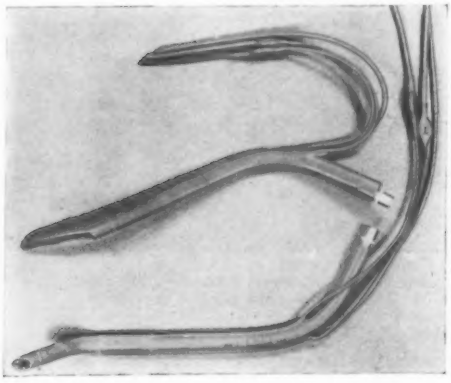

FIG. IX. Macintosh and Leatherdale endobronchial tubes. Upper: For left pneumonectomy. Lower: For right pneumonectomy.

Add to this the possibility of a high origin of the right upper lobe bronchus (Fig. XII), or distortion of the bronchial tree due to disease and the method becomes quite unsafe.

After studying the normal anatomy of the right main bronchus from bronchograms, Green and Gordon of St. Georges Hospital, London, designed in 1955 an endobronchial tube with its distal 4 cm. angulated 15 degrees to the right (Fig. XIII). On this portion is a lateral slot with an inflatable cuff attached to its margins. This slot in situ corresponds to the position of the orifice of the right upper lobe bronchus and because of its communication with the main airway of the tube, it allows inflation of the right upper lobe with the remainder of the right lung. The tube as described, is placed blindly with a stilette. There is a stiff rubber hook on

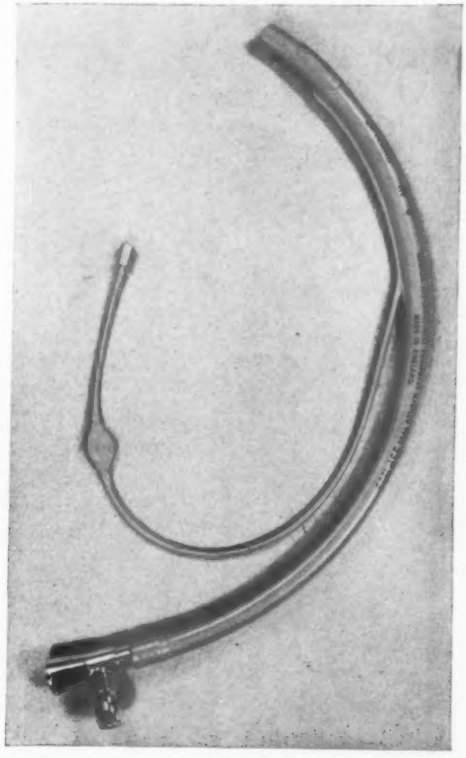

FIG. X. Machray short cuffed left endobronchial tube.

the left side of the tube which catches on the carina during insertion to indicate that the tube has reached its destination.‡

A modification of this tube by Pallister (cited by Mansfield, 1957) allows insertion by a Magill introducing bronchoscope.

The Gordon-Green tube has now made right endobronchial anaesthesia a more reliable proposition and it is extremely valuable for operations involving the left main bronchus.

The problem of anaesthetizing for the surgical correction of bronchopleural fistula and empyema following right upper lobectomy has been made lighter in recent years by the introduction of two tubes designed to block the fistulous opening from the rest of the bronchial tree. The first, described by Vellacott in 1954 (Fig. XIV) consists of a double cuffed single lumen tube reinforced with spiral wire and stiffened with an inbuilt malleable stilette. The lower of the two cuffs is placed opposite the right upper lobe orifice to occlude it and the upper cuff is in the trachea. Between these cuffs and to the left is cut a deep hole one inch long to provide an airway to the left main bronchus. The tube is positioned with an intubating bronchoscope. The second tube described by Green in 1958 has a further advantage (Fig. XV). It has two small bronchial cuffs instead of one and these are intended to lie above and below the upper lobe orifice. Between these cuffs is the inlet of a fine inbuilt sucker tube. A blocker that sucks always has an advantage over a non-sucking occluder since fluid under tension has only to overcome the mechanical barrier of the pressure within the occluding cuff to spread beyond.

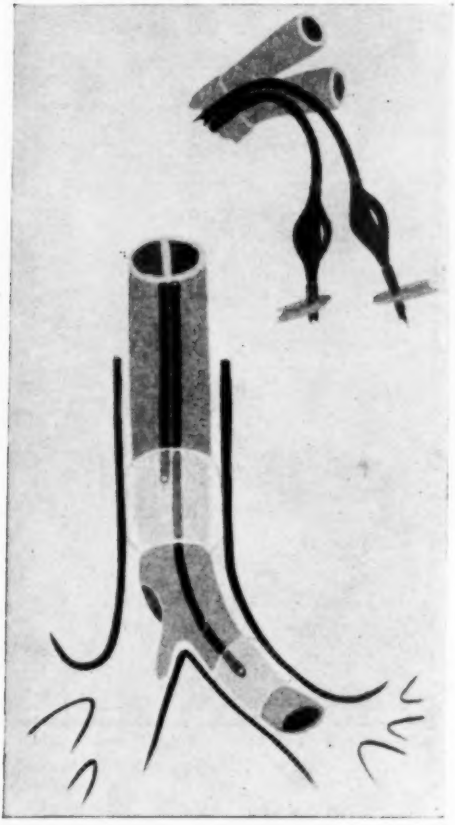

FIG. XI. Carlens' double lumen catheter. (By permission of *Anesthesiology*.)

FIG. XII. Radiograph showing abnormal high origin of right upper lobe bronchus.

‡The manufacturer's agents in Australia notified this department that this tube was to be temporarily withdrawn from sale to improve the method of attachment of the carinal hook. (See Green, R. [1959], *Anaesthesia*, vol. 14, page 295.)

A simple Vellacott-type tube can be quickly made (Fig. XVI) by placing a detachable cuff approximately two inches above the cuff of a No. 9 endotracheal tube. A hole 2.5 cm. long is cut on the convexity of the tube between the two cuffs. The bevel is recut to within 1 cm. of the lower cuff and with a shallow angle facing downwards and laterally when in position. This tube can be inserted under vision on a Magill bronchoscope. With this type of tube the right lower and middle lobes are ventilated as well as the left lung. This is important in patients with limited pulmonary reserve who would do poorly with a one lung anaesthetic.

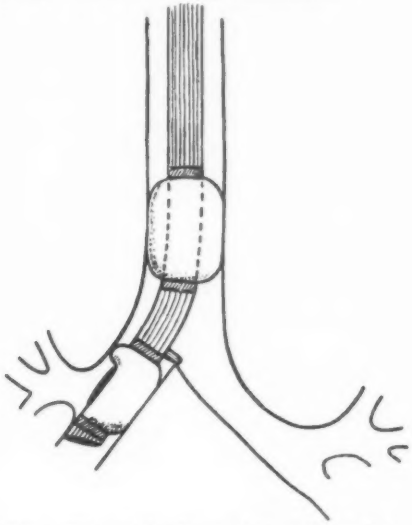

FIG. XIII. Gordon-Green right endobronchial tube.
(By permission of *Anaesthesia*.)

Further refinements in endobronchial anaesthetic technique have been reported, especially by Gebauer (1950) for use in tracheobronchial reconstruction. Here the trachea or one or other bronchus may be opened for considerable periods during the anastomosis. To maintain sufficient ventilation a divided bronchus may have to be intubated via the thoracotomy and, if necessary, anaesthesia given independently to each lung from two machines.

Because of the risk of an endobronchial cuff being punctured during this type of surgery Pallister (1959) has described a three cuffed tube with a reserve cuff inside the usual endobronchial one.

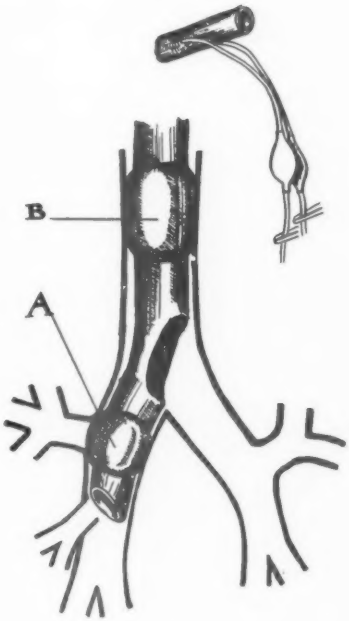

FIG. XIV. Vellacott tube.
(By permission of *British Journal of Anaesthesia*.)

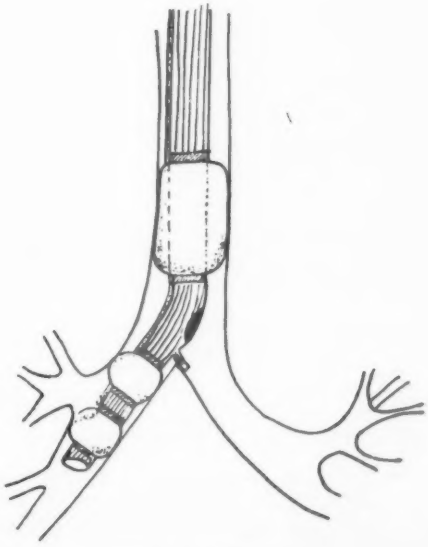

FIG. XV. Green's tube for excluding the right upper lobe bronchus.
(By permission of *Anaesthesia*.)

By choosing one of these methods of endobronchial anaesthesia the following advantages may accrue.

1. Ventilation of the normal lung can be controlled at all times.
2. The lung on the side of operation can be deflated to give a quiet, adequate exposure.

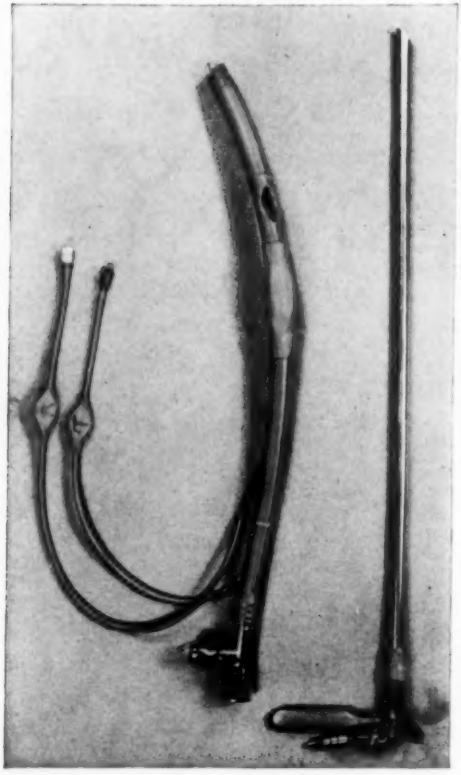

FIG. XVI. Magill intubating bronchoscope and easily made Vellacott-type tube (see text).

3. The lung on the side of operation may be expanded in certain techniques to indicate intersegmental planes.
4. The surgeon can aspirate the bronchial tree through the stump of the resected bronchus without interfering with ventilation.
5. The open bronchial stump can be sutured at leisure.
6. The bronchial stump can be tested for leaks without withdrawing the endobronchial tube into the trachea if the anaesthetic tube has a tracheal as well as a bronchial cuff.

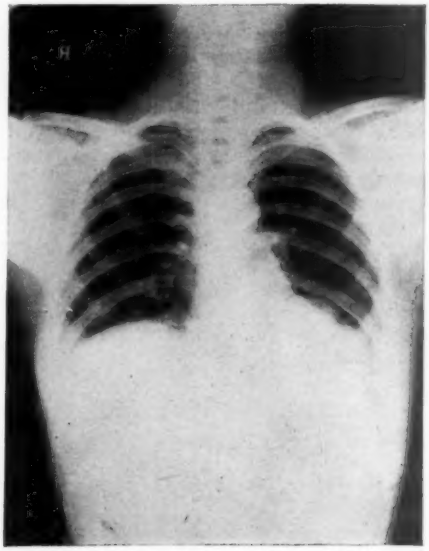

FIG. XVII. Case 1. Secondary chorion-carcinoma left lower lobe.

CASE REPORTS

The following recent cases illustrate endobronchial techniques.

Case 1

A woman of 23 years was to have an exploratory thoracotomy because of a mass in the left lower lobe with collapse of the basal segments (Fig. XVII). She had a productive cough and haemoptysis. She had some loss of weight and a haemoglobin of 50% had necessitated a blood transfusion of 4 pints.

After induction with thiopentone and d-tubocurarine a Magill blocker with a short cuff was passed through a Negus bronchoscope and placed in the lower lobe bronchus just below the origin of the apical segmental bronchus. A No. 7 Magill cuffed tube was inserted into the trachea alongside the blocker. During the operation some blood from the affected segments was aspirated through the blocker. The basal segments of the left lower lobe were removed, the resection being assisted by inflating the apical segments to demarcate them from the basal segments.

The specimen consisted of a cystic tumour containing much clot and fresh blood. Section showed chorion-carcinoma.

Comment: a cystic chorion-carcinoma with evidence of fresh bleeding and pre-operative indication of bronchial communication could have proved embarrassing under simple endotracheal anaesthesia. Right endobronchial anaesthesia would not have protected the apical segment of the lower lobe.

FIG. XVIII. Case 2. Mottling of right lower zone due to repeated haemoptyses.

Case 2

A boy of 15 years was admitted because of massive haemoptysis (Fig. XVIII). In the eighteen hours prior to operation he had four episodes totalling 1,800 ml. of blood loss. An emergency right lower lobectomy was performed. The patient was very apprehensive and was considered to be unsuitable for endoscopic manipulation under local anaesthesia.

After induction with thiopentone and suxamethonium, a Magill blocker was inserted through a Negus bronchoscope into the lower part of the right main bronchus, opposite the orifice of the right middle lobe bronchus. A No. 7 cuffed Magill tube was placed in the trachea. The specimen showed bronchiectasis, with the lower lobe and its bronchi full of blood.

Comment: Local anaesthesia, if possible, would be safer for inserting the blocker in such a case.

Blocking of the lower lobe bronchus ensures the integrity of the airway to the right upper lobe as well as to the opposite lung.

Case 3

A man of 52 years had a left upper lobectomy and removal of a malignant adenoma from the intermediate part of the main bronchus. The defect was closed by a flap from the postero-superior aspect of the left upper lobe bronchus which was free from adenoma (Fig. XIX).

After induction with thiopentone and d-tubocurarine, a modified Gordon-Green tube was placed by direct vision in the right main bronchus. Ventilation of the whole of the right lung was uninterrupted throughout the plastic reconstruction of the left bronchus. By deflating the bronchial cuff and inflating the tracheal cuff the left bronchial suture line could be tested.

Comment: A Carlens catheter was not suitable because of the involvement of the left main bronchus in the surgery. A blocker could not be placed distal to the tumour to protect the lower lobe because of the probability of traumatizing the tumour and initiating haemorrhage. A blocker proximal to the lesion in the left main bronchus, although feasible for the resection, would have been unsafe during the reconstruction phase. Simple endotracheal anaesthesia would not have provided adequate ventilation during the bronchial suture.

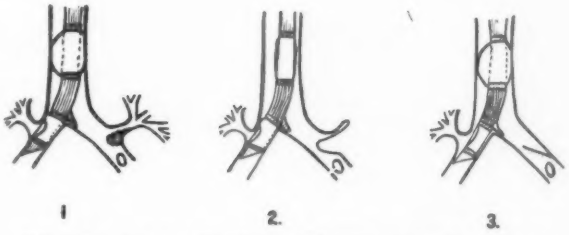

FIG. XIX. Case 3. Resection of left upper lobe and portion of left main bronchus for malignant bronchial adenoma.

Case 4

A woman of 69 years with a past history of hypertensive cardiac failure, was readmitted to hospital with a recurrence of a right upper lobe abscess. Antibiotics cleared the purulent sputum but she continued to spit blood. A right upper lobectomy was performed. Following the operation the apical drainage tube continued to drain pus and air. Two weeks after the lobectomy a 1-4 rib right thoracoplasty with drainage of the empyema was performed with the patient in the left lateral position.

The anaesthetic problem for this operation was one of empyema with a right upper lobe bronchus fistula (Fig. XX), in a frail elderly lady, with a past history of hypertensive heart failure, in whom one lung anaesthesia was precluded because of the inadequate pulmonary reserve. After 4 per cent. lignocaine topical preparation of the larynx and trachea, with the patient in the sitting position, the modified right endobronchial tube, described earlier, was placed under vision with a Magill bronchoscope, to block the right upper lobe fistula. This tube also provided aeration for the right lower and middle lobes and the whole left lung. When the positioning of the tube was finalized the patient was induced with thiopentone and d-tubocurarine.

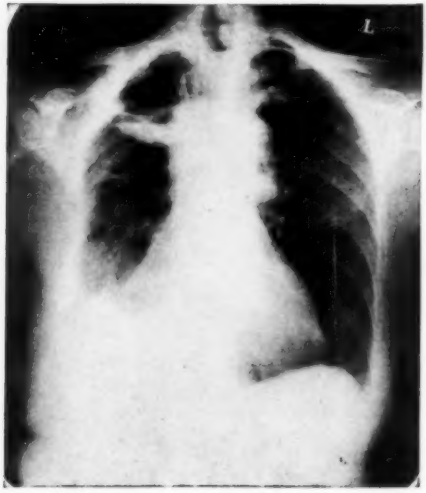

FIG. XX. Case 4. Empyema and bronchopleural fistula following right upper lobectomy.

Comment: In a patient where the airway is uncertain until the anaesthetic tube has been accurately placed, it is best to introduce the tube under local anaesthesia. The sitting or semi-recumbent posture for intubation is essential in these cases.

Case 5

A man aged 53 years was admitted because of intense dyspnoea on exertion, cough and chest pain. He was comfortable at rest only. An X-ray showed a giant air cyst of the right lower lobe which was causing collapse of the right upper lobe (Fig. XXI). Bronchoscopy was normal and ventilatory capacity tests were interesting in that they showed a marked difference in findings between those done at rest and those done after exercise. At rest the picture was one of moderately severe generalized emphysema, in other words better than would have been expected considering his poor exercise tolerance. His ventilatory response to exercise was then shown to be double normal and about 75 per cent. above the usual range for emphysema. This accounted for the discrepancy between the patient's poor exercise tolerance and the result of the simple ventilation tests. Bronchospirometry confirmed that the function of the right lung was greatly impaired by the presence in it of the cyst. At operation a large cyst was seen which represented most of the apical, posterior basal and lateral basal segments of the lower lobe. The upper and middle lobes were collapsed. A right lower lobectomy was performed. Because of the probability, from the ventilatory capacity tests, that the cyst would ventilate with

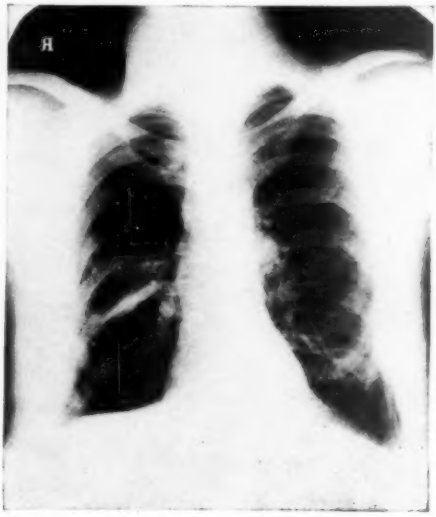

FIG. XXI. Case 5. Giant air cyst shown by tests to be ventilating.

positive pressure respiration, it was decided to use a Carlens double lumen tube for anaesthesia. The induction had been with thiopentone and suxamethonium and, after gentle inflation with oxygen, the Carlens catheter was introduced. Immediately after intubation both lungs were deliberately inflated to see what would be the effect with the chest still closed. Within three minutes the patient became cyanosed and showed signs of mediastinal displacement to the left. The right tube of the Carlens catheter was opened to the atmosphere and anaesthesia maintained by the left lung alone. The colour of the patient immediately returned to normal. This left sided anaesthesia was continued until the right lung was exposed by the surgeon. Both lungs were now inflated to demonstrate the cyst which ballooned out through the wound. After its removal the cyst was shown to be capable of holding 4 litres of air. By adjusting the volume of gases in the right lung and clamping the line from the right tube of the Carlens catheter, the cyst could be held at any tension convenient to the surgeon while maintaining

normal ventilation of the left lung through the left tube. When the right lower lobe had been removed, two-lung ventilation was resumed until the end of the operation.

SUMMARY

The indications for and development of endobronchial anaesthetic techniques are discussed. The need is stressed for the wider use of endobronchial methods so that the difficult case can be managed efficiently.

Reports of recent cases illustrating endobronchial anaesthesia are presented.

ACKNOWLEDGEMENTS

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THE USE OF THE JEJUNUM IN UPPER ABDOMINAL SURGERY AND A COMPARISON WITH OESOPHAGO-GASTROSTOMY*

By Douglas Robb

From the Unit for Thoracic and Cardiac Surgery, Green Lane Hospital, Auckland

IN vascular surgery of recent years a great variety of additional procedures have added to the surgeon's resources through the use of autografts, homografts and synthetic materials. For example there is the achievement of otherwise impossible anastomoses as in a long coarctation of the aorta, or the bridging of a gap made by aneurysmal disease or by trauma.

In the surgery of the alimentary tract it has become possible to achieve similar ends through the freer use of replacement segments. In this area, however, it has been done almost entirely by borrowing within the patient's own organs and not resorting to homografts or synthetic materials. This has been made possible by the great mobility of many parts of the digestive tube and, if not its redundancy in length, by the fact that we can get along with less than the normal length, in many parts of it. In these respects, the arterial tree and the alimentary canal stand in marked contrast.

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In these alimentary mobilizations the jejunum has an eminent position, and it is proposed to review and evaluate some of them, drawing on the experience of others to fill gaps in our own. It is not intended in any way to play down the usefulness of the stomach and the colon in some of the situations to be considered; merely to give fuller attention to the jejunum. It may be some years before a full appraisal of the alternatives is possible. However, an interim comparison between the use of the jejunum and oesophago-gastrostomy will be made.

The use of the jejunum in jejunostomy, gastrojejunostomy and in the Billroth II type of gastrectomy will not be discussed in particular, being long established and well understood. Nor will its use in reconstructions in the urogenital or other systems be touched on.

Clinical Experience with the Jejunum

The clinical experiences of the Unit in this field comprises the following 17 cases, ages being given at the time the jejunal operation was performed.

1.—After resection of oesophageal stricture due to hiatus hernia — 6 patients.

(1 Roux — 5 isolated segments)

Male	1 2/12 yrs. (14 mths.)	Isolated segment
Female	8 years	Isolated segment
Male	10 years	Roux
Male	59 years	Isolated segment
Male	59 years	Isolated segment
Female	63 years	Isolated segment

2.—After resection of oesophageal stricture following operations for achalasia — 2 patients.

Female	39 years	U-loop converted to Roux
Female	66 years	Isolated segment

3.—After radical resections for carcinoma stomach — 5 patients.

4 Males 77, 75, 74 and 35 years
1 Female 69 years
(All isolated segments save 1 U-loop)

4.—After total gastrectomy for non-malignant condition — 1 patient.

1 Male	29 years	Isolated segment

5.—For bleeding varices in portal hypertension — 3 patients.

1 Male	6 years	Isolated segment
1 Female	13 years	Isolated segment
1 Male	53 years	Isolated segment

Summary

After resection of stricture—	
Due to hiatus hernia	6
Due to operation for achalasia	2
After radical resection for Ca.	5
After total gastrectomy (not Ca.)	1
For bleeding varices	3
Total:	17
Roux loop	1
U-loop	2
Isolated segment	14
Total:	17

We have not had occasion to use the jejunal segment to relieve dumping after partial gastrectomy, as advised by Henley (1952) and by Fallis and Barron (1958). The latter describe a neat way of using the existing loop attached to the stomach to get back to the duodenum; Walters and Nixon (1959) describe a similar procedure.

Parts of the colon, either the right side with or without a small part of the ileum and the ileo-caecal valve, or segments of the transverse or descending, have also been used (Neville and Clowes, 1958) for bridging oesophageal gaps and undoubtedly, judging from a small experience in our Unit, these do well when it is necessary to reach the neck, a retrosternal tunnel lending itself nicely for the transit. We have not enough experience to distinguish between the value of the two organs and no doubt some years will be required to arrive at a sound judgment. The colon is not free from the complication of fistula formation and moreover requires careful antibiotic and other preparation for some days before the operation if it is to be used; however, the mobilization of a long colonic segment with a good blood supply would seem to be easier than with the jejunum, length for length.

PURPOSES OF THE JEJUNAL SEGMENT

1.—To bridge a gap after oesophageal or gastric resection

Examples of this occur after chemical or traumatic damage, or after resection for other simple or malignant conditions, and may be found at any level from the cervical portion of the gullet down to the duodenum.

Strictures may leave only an inch or two of healthy tissue at the upper end of the gullet for anastomosis but the damaged portion may be left *in situ*. When the upper anastomosis lies at this level or in the thorax above the arch of the aorta, the jejunum does not commonly make the best bridge, though it has stout advocates; either a tube of stomach, or the ascending colon, sometimes the transverse colon, being more adaptable to that height. Jejunum however will almost always reach to a point below the level of the arch. It is therefore available for resections of the cardia and for resections of the stomach up to total resection. Sometimes the gap is bridged palliatively as a by-pass without resection of the obstructing lesion.

2.—To form a reservoir

Both in length and diameter a jejunal segment can usually be provided which will give greater capacity after partial or total gastrectomy than when the oesophagus is joined on to the duodenum or to a narrow tube of greater curvature of the stomach.

3.—To act as an anti-reflux device

This function relies on the jejunal segment's strong sense of peristaltic direction and provides us with probably our best mechanism when this is important.

An interesting early example of this purpose was Tavel's proposal (quoted by Habif, 1959) for a non-leaking gastrostomy using a jejunal segment between skin and stomach. Merendino has been the prophet of this use of the jejunum, and with Thomas (1955) gives a later appraisal of his experience.

4.—To act as a vein-block in portal hypertension

Here the object is to discourage the formation of venous channels running up and joining the peri-oesophageal and submucous veins of the lower gullet on their way to the azygos system. Other measures for this purpose include high gastric transection and direct suture of the submucous varices. A vascular anastomosis such as a porto-caval shunt will almost always have been done, or found impracticable before these procedures come up for consideration.

5.—To receive bile and pancreatic secretions after damage to the common bile duct and resection of the duodenum and pancreas for malignancy. In the former case it is better than duodenum on account of its more alkaline milieu and its less vigorous motility, and in the latter it is the only repository available. Little more will be said about this section as we have little experience of resection for carcinoma of pancreas. In recent bile duct reconstructions we have succeeded in 4 cases without recourse to bowel; in the remaining case, our first, the first part of the duodenum was used, so far successfully. Today I would use a Roux loop, after the style of Rains (1959) and of Maingot (1959) if I could secure no reliable lower segment of duct.

It is clear that in any given situation, more than one of these purposes may be sought. 1 and 2 often go together, 3 or 4, or 3 and 4 may be desired without 1 being needed. In bleeding varices both 3 and 4 are desired, and when successful it is hard to know which to credit.

METHODS OF USING THE JEJUNUM

1.—Roux loop

This is the time-honoured method, whereby after division of the jejunum the upper cut end is put end-to-side into the jejunum further down, leaving the other cut end and adjacent portion with its blood supply intact for passing upwards and anastomosis to the oesophagus as required. Allison and da Silva (1953) have given details of the technique. It is a useful method, requiring great attention to detail, however, to avoid vascular and mechanical complications. It is not applicable to situations where it is desirable and possible to restore continuity through the duodenum. It is valuable for common bile duct surgery. Our limited experience with it in children is unfavourable. Jezioro and Kus (1958) give details about vascular division in preparing a long jejunal loop, and also discuss the use of the lower ileum as an anti-reflux device with the valve and a cap of caecum.

2.—Inverted U-loop

Here the highest-reaching point of the upper jejunum is used for side-to-end anastomosis to the oesophagus or stomach, and side-to-side openings may be made between the limbs as thought necessary. It is essentially the Polya or Billroth II junction applied to the oesophagus instead of to the usual small stomach segment. It can be used also for bile duct reconstruction. It is the quickest and easiest method to apply but it does not usually reach as high as 1 or 3. In our hands it is by no means devoid of stricture formation at the junction with oesophagus, nor of other troubles such as obstruction of the afferent side or of the side-to-side opening by intussusception. One such case was relieved by converting it into a Roux loop.

3.—Isolated segment

Here a loop 6 to 15 inches long is chosen, usually some 12 to 24 inches down the jejunum and separated by division of the bowel at each end, the continuity being restored by end-to-end union. The loop on its pedicle is now free for passing up through the mesocolon and behind the stomach and anastomosis to the oesophagus above and stomach or duodenum below. The mesentery is divided towards its root to make the pedicle smaller. Habif (1959) suggested a useful manoeuvre to secure the blood supply more surely, by dividing bowel and mesentery at the upper end of the loop, but bowel only at the lower. This allows conservation of the lower arcades, but means that the jejuno-jejunal restoration anastomosis has to be above the mesocolon near the stomach. There is no great harm in this, but we found in one case that by dividing the arcades for a distance down the distal jejunal limb and conserving more on the lower end of the isolated segment, that the best of both worlds could be achieved and the restoration anastomosis made to lie below the mesocolon in a more natural position.

An interesting variation in the application of such a loop was devised by Boerema (1955) of Amsterdam. He used a large Murphy's button type of appliance for a snap junction of the oesophagus to the upper end of the jejunum. The operation of partial oesophago-gastrectomy could thus be performed entirely from the abdomen yet radically, the bobbin slipping up into the chest and being retrieved from the mouth by a thread about the 12th day. We have used this with some satisfaction, but decided in the end that a thoraco-abdominal exposure, or an extended abdominal incision (for example the partial sternal division of Wangensteen) was usually called for. Direct suture under vision, though a little more time-consuming, was simpler and more reliable. The Boerema device, however, once experience with its use has been gained, might spare some valuable operating time on an elderly patient who is having a palliative by-pass implant.

TECHNICAL POINTS

A number of complications and difficulties have been encountered which point to the need for great care and delicacy in carrying out all these manoeuvres.

1.—The anastomosis

Meticulous two-layer anastomosis under good light and access are important. Formerly we would have insisted on interrupted fine silk or nylon all-coat sutures with knots on the lumen, for all oesophageal unions. Now I think continuous catgut, knotted at intervals, for this layer may be as good and is quicker. Even so, leaks do occur and must be anticipated. These leaks may close after conservative management and drainage.

2.—Blood supply

Particularly in children and in the elderly this must be studied anxiously. Discoloration of the loop merely through hanging over the edge of the wound is a warning and a period of observation while doing the restoration anastomosis, is of great value, and allows one to cut off an inch or two if it looks dubious before the final suturing. We have had in one case strictures developing at both upper (oesophago-jejunal) and lower (jejuno-gastric) junctions which needed re-fashioning. The blood supply of the lower 1 or 2 inches had been queried on the first occasion and fibrosis from inadequacy of the circulation may have been the cause. Alternatively it might have been from the acid gastric juice but the stricture was remarkably concentric. We have had two strictures that required revision at the upper junction and several minor degrees of obstruction at this point.

3.—Relation to hiatus

The loop will usually pass through the hiatus, with one anastomosis above and one below the diaphragm. The hiatus itself can often be left largely undisturbed by treating it gently, and by dividing the diaphragm peripherally at the costal margin or near to the muscular rim of the hiatus. The jejunal wall must be stitched to the hiatus preferably above and below to diminish the likelihood of a segment being drawn up into the chest by the negative pressure. We had severe trouble with this (combined with stricture at both ends) in one case necessitating three subsequent operations for the replacement of distended coils of jejunum back into the abdomen. Even after re-anastomosis and stitching of the jejunum to the edges of the hiatus prolapse recurred, and most of the segment had to be resected.

4.—General disposition of the loop

There is always the danger of kinking and obstruction from these more complicated abdominal manoeuvres. All care should be taken to cover raw surfaces, to close apertures in mesenteries and to ensure a comfortable lie of the loop without tension.

5.—Pyloric relaxation

Pyloro-myotomy or plastic operation or by stretching from within is needed in all cases where the resection has sacrificed the vagus nerves.

COMPLICATIONS

The following have been encountered:

1.—Roux loop

One fatal kinking at the restored diaphragmatic hiatus in a boy of 10 years.

2.—U-loop

In one patient, whose original trouble was stricture after an early operation of cardioplasty for achalasia, there was post-operative hiatus hernia of the loop. Afferent loop obstruction required first side-to-side anastomosis and later re-fashioning as a Roux loop and gastrectomy and dilations of the stricture at the oesophago-jejunal junction. The final result was a good one, without stricture, dumping or malnutrition.

In an elderly man after radical gastrectomy, a fatal kinking and strangulation at the duodeno-jejunal junction.

3.—Isolated segment

In one patient (originally an abdominal Heller's operation for achalasia) with later stricture and resection of the cardia with jejunal loop insert, there was a stricture at the oesophago-jejunal anastomosis needing a re-anastomosis. There was also recurrent pyloric obstruction after a Finney type of pyloroplasty, needing posterior gastro-jejunostomy. Final result was satisfactory.

A child of 18 months had first an abdominal and then a thoracic repair of a hiatus hernia and later a stricture and resection with

insertion of a segment. There followed prolapse of the segment into the chest and partial obstruction at both ends of segment, gastrostomy, re-fashioning of both anastomoses and replacement of loop. A fair result was obtained in spite of prolapse yet again necessitating its removal.

Two elderly patients with radical total gastrectomy died of shock and peritonitis three and four days respectively after the operation. There were no anastomotic leaks.

One male of 35 years with a radical total gastrectomy for carcinoma did well for nearly two years after surviving a leak and empyema at the upper anastomosis.

One case of portal hypertension had a later laparotomy for ileal obstruction.

RESULTS

This list of complications and difficulties is formidable enough but there are more favourable examples.

Three cases of portal hypertension whose isolated segments function well with only slight difficulties and who have had no haemorrhage since the insertion sixteen, fifteen and five months ago. The last patient died unexpectedly in hepatic coma five months after the loop was inserted.

Two patients, originally achalasias, going on to stricture after cardioplasty and abdominal myotomy respectively, are finally well after several complications had been dealt with surgically, one with a Roux and one with an isolated segment.

Two patients had radical resections for carcinoma and isolated segments. One did well until death from metastases twenty-one months later and the other is well two months after operation.

Three patients with stricture from hiatus hernia, aged 8 years, 59 years and 63 years, required resection and have done well with isolated segments. One youngish man with a similar segment after total gastrectomy for duodenal ulcer, hypertrophic gastritis and a family history of carcinoma of the stomach, is in excellent shape three years later.

These results may be summarized in the following two tables:

RESULTS IN 17 JEJUNAL CASES

Roux loop — Fatal kinking	1 case
U-loops—	
Fatal kinking	1 „
Finally well — Roux	1 „
Isolated segments—	
Excellent	8 cases
Well	2 „
Finally well	2 „
Post-operative death	2 „

ISOLATED JEJUNAL SEGMENT — 14 CASES

After hiatus hernia and stricture	5 cases
Done well, 4-18 mths.	4 „
Many complications; may end well	1 case
After resection for carcinoma	4 cases
Early post-operative death	2 „
Well until death metastases, 21 mths.	1 case
Well — recent case	1 „
For varices — excellent	3 cases
After achalasia — finally good	1 case
After total gastrectomy — excellent	1 „

The patients who have done well, either at once or after correction of complications, are most grateful for the relief from dysphagia and for the enjoyment of solid foods. There seems to be a minimum of digestive upsets, even when the stomach has been completely removed, capacity being adequate if not normal and appetite normal. Power to belch and to vomit after the jejunal segment seems to vary. One patient has had nausea but could not vomit (once in three years) and has only a little belching. Another vomited once in three months. Another, quite symptom-free, showed reflux into the oesophagus in the supine position in the X-ray. A number of radiological examinations show the segment to lie well without distension or dis-

tortion, and the barium to pass along without undue delay or hurry. Two patients however, a child and an elderly woman, have had unexplained intestinal looseness — this is mentioned by Habif also. Merendino and Thomas also found variable results in regard to the ability to vomit after insertion of the loop, but on the whole gave a favourable report; 48 per cent. could not vomit, a few could, and a few could regurgitate from the oesophagus and the segment.

COMPARISON WITH OESOPHAGO-GASTROSTOMY

The chief alternative to the use of the jejunum in many of these situations is oesophago-gastrostomy, after resection of varying portions of the stomach and oesophagus as dictated by the nature and position of the original lesion and particularly the level of the upper division of the oesophagus. In all such cases release of the pylorus, either by digital stretching or by a myotomy or plastic pylorotomy is considered essential. Our experience is greater with this operation and its results extend over a longer period of time.

In the tables below are set out the clinical material, first separated into non-malignant conditions (19 cases) and malignant conditions (20 cases) and then added together. The results are classified as excellent, good or poor (the fatal cases being excluded) on a clinical assessment by the writer. The assessment concerned only the reconstruction as such—it might be excellent say for two years until a local recurrence of cancer overtook the patient. To be judged excellent the patient had to maintain good health and condition without dysphagia or stricture and without troublesome reflux. A good result was one where the patient kept up his strength, perhaps even continued at work, but had to have periodic dilatations for stricture, or suffered more or less severely from reflux symptoms. A poor result meant early and severe troubles of this sort with poor general condition.

OESOPHAGO-GASTROSTOMY AFTER RESECTION — FOR NON-MALIGNANT CONDITIONS NUMBERING 24 CASES

	Cases	*Deaths*
For hiatus hernia and stricture—		
Juvenile	7	3
Adult	7	1
After caustic stricture	5	1
Oesophagitis—		
Cause unknown	1	–
Toxaemia of pregnancy and vomiting	1	–
Stricture from foreign body	1	–
For bleeding varices	1	–
After resection for cardiospasm	1	–
	24	5
Post-operative deaths—		
Early	4	
Late	1	(P.B.)
Anastomosis—		
Above aortic arch	7	
Below aortic arch	17	
Major post-operative complications	1	

The results in the 19 survivors of these 24 cases are set out in the next two tables:

OESOPHAGO-GASTROSTOMY — SIMPLE CONDITIONS

Results	*No.*	*Ages*	*Average post-operative duration*
Excellent	10	3, 5 to 40 one 73	5 years 2 to 9
Good	8	2½ to 81	2½ years
Poor	1	69	3½ years
Total	19		

OESOPHAGO-GASTROSTOMY — SIMPLE CONDITIONS

Amount of stomach remaining	*Excellent*	*Good*	*Poor*
Whole or nearly so	6	1	–
Half — — —	2	2	1
One-third or less	1	4	–
Not clear — —	1	1	–
Anastomosis re aortic arch:			
Above — —	5	–	–
Below — —	5	8	1

Oesophago-gastrostomy after resection for malignant disease of oesophagus or stomach number 20 cases, after discarding those where the post-operative course was too short to allow a useful evaluation. The results are set out in the following two tables:

RESULTS OF OESOPHAGO-GASTROSTOMY AFTER RESECTION FOR MALIGNANT DISEASE

		Ages	*Average of duration*
Excellent	12 cases	50-77	3 years
Good	5 cases	54-67	2 years
Poor	3 cases	62-70	7 months

OESOPHAGO-GASTROSTOMY AFTER RESECTION FOR MALIGNANT DISEASE

	Excellent	*Good*	*Poor*
Amount of stomach remaining:			
Whole or near whole	2	2	1
Half	6	1	–
One-third or less	4	1	2
Not clear	–	1	–
Level of anastomosis:			
Above arch	3	4	1
Below arch	9	1	2

There was also one excellent result over four years after a total gastrectomy and oesophago-duodenostomy after resection for malignancy.

Comparing the two groups it is seen that there is a slightly greater proportion of both excellent and poor results in the group with malignant disease, but that the duration of the observation was shorter, no doubt due to the supervention of recurrences and the generally older age group. The non-malignant group included a number of children. Regarding the amount of stomach remaining after the resection, there were some differences but it seems that excellent results may be expected after any degree of resection up to total. Likewise the level of the anastomosis seems to make little difference whether it be high, even in the neck, or below the arch of the aorta. However, for what the few figures are worth the high anastomoses (with more stomach left) gave better results in the simple than the malignant cases, and the low anastomoses (with less stomach left) were better in the malignant than in the simple cases.

The next tables put together the results of all the examples of oesophago-gastrostomy after resections for both simple and malignant conditions, 39 in all. It will be seen that the differences noted in the last sentence of the previous paragraph have practically vanished.

OESOPHAGO-GASTROSTOMY — ALL CONDITIONS

Results	*No.*	*Ages in years*	*Average duration post-operatively*
Excellent	22	3-77	4 years
Good	13	2½-81	2 years
Poor	4	62-70	1 year
Total	39		

OESOPHAGO-GASTROSTOMY — ALL CONDITIONS

Amount of stomach remaining	*Excellent*	*Good*	*Poor*
Whole or nearly so	8	3	1
Half — — —	8	3	1
One-third or less	5	5	2
Not clear — —	1	2	–
Anastomosis re aortic arch:			
Above — —	8	4	1
Below — —	14	9	3

In comparing this conjoint series with the tables giving the results of the isolated jejunal segment cases, we may exclude the Roux loop and the U-loop examples as being too few to be reliable. We then have 14 isolated jejunal segment cases to set against 39 oesophago-gastrostomies. The former are on the whole much more recent than the latter and it must be admitted they are fraught with more post-operative complications. The post-operative death rate has been about the same. The proportion of excellent results is not very different in the two groups. In the case of bleeding varices we have 4 good results in respect of no further bleeding to date, 3 with jejunal segments and one with a oesophago-gastrostomy.

SUMMARY

We may summarize by saying that we have two good procedures available in the isolated jejunal segment and in oesophago-gastrostomy, the jejunal segment being somewhat more tedious and delicate in execution, and more prone to post-operative complications and sequelae. It should, therefore, be reserved for circumstances with a particular indication such as the need for capacity and the need to guard against reflux as in varices. It is not particularly suited for very high anastomoses where oesophago-gastrostomy (if the stomach will reach) is a good operation and the jejunum is likely to be contested chiefly by the use of colonic segments.

The experience recorded here has been largely gained within the Unit for Thoracic and Cardiovascular Surgery at Greenlane Hospital. Cases operated on by Mr. Rowan Nicks, Mr. John Borrie, Mr. P. F. Howden, Mr. B. Barratt-Boyes and Mr. D. S. Cole are gratefully acknowledged.

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A COMBINED VENOUS RESERVOIR AND DEFOAMING CHAMBER FOR USE IN A HEART-LUNG BY-PASS CIRCUIT*

By B. G. Barratt-Boyes and S. Yarrow

Cardio-Thoracic Surgical Unit, Green Lane Hospital, Auckland

BLOOD collected from the patient into the venous side of a heart-lung machine comes from both the superior and inferior cavae (venous return) and from the open heart (coronary sinus and bronchial artery return). Because of the necessity for defoaming the blood from the open heart before it joins the main venous pool, numerous methods of collection have been devised and in some circuits a reservoir for venous return has been completely omitted. Perhaps the most frequently used system is collection of the venous return into a larger venous reservoir and of open heart return into a separate smaller defoaming chamber. This arrangement requires two separate collecting reservoirs and a device for emptying blood from the defoaming chamber, either intermittently or preferably continuously, into the main venous circuit and is therefore complex.

To overcome these difficulties and provide a simpler system a venous reservoir has been designed which acts as a receiver for both the venous and open heart return. Venous blood is drawn into the bottom of the reservoir by gravity suction while blood from the open heart is pumped into a defoaming chamber in the top of the reservoir. Although we are aware that venous reservoirs incorporating this principle have recently become available commercially, we consider that the present design possesses many advantages and warrants detailed description.

The reservoir** (Figs. I to IV) consists of a calibrated perspex cylinder (A) of 600 ml. total capacity with stainless steel screw on caps (B and C) at either end. A small stop cock (D) is fitted to the lower end plate for blood sampling and a much larger stop cock (E) for opening and closing the reservoir to atmospheric pressure, perforates the upper end plate. The reservoir is clamped vertically to an adjustable slide on which it can be raised or lowered to vary the amount of gravity suction.

Venous blood enters the reservoir by gravity from below via a half-inch diameter stack pipe (F) which films the blood on to the side of the perspex cylinder somewhat above the 300 ml. calibration mark. By keeping the operating level of blood in the reservoir below this point the venous return films evenly on the side of the cylinder and any pressure fluctuations produced by the venous pump in the blood collecting in the reservoir are not transmitted along the venous lines to the cavae. The venous pump draws blood from a half-inch connection (G), the opening of which is flush with the bottom of the reservoir.

Blood from the open heart is delivered by Sigmamotor pumps to the top of the reservoir via two $\frac{3}{8}$-inch connectors (H) which project into the middle of the defoaming chamber. This chamber consists of an outer stainless steel casing (I) which is clipped to the under surface of the top plate (B) by a bayonet fitting and is open at the bottom. The casing is packed with 28 discs of 25 mesh to the inch stainless steel gauze (J) each separated by a spring washer and held in position by a base plate (K) and a spring clip (L). The topmost 14 discs have 2 holes punched to accommodate the steel connectors (H) while all the discs and the base plate have a central hole through which passes the $\frac{1}{4}$ inch diameter stainless steel priming tube (M) which terminates above the lower end plate of the reservoir. The open heart return is thus delivered into the centre of the stack of gauze discs, an arrangement which prevents any foam escaping through the large stop cock (E) at the top of the reservoir. The blood is defoamed and filtered as it passes downwards and leaves the defoaming chamber as a continuous film on the outer surface of the

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**Manufactured by the Auckland Industrial Development Laboratories, Department of Scientific and Industrial Research.

priming tube which carries it, without recognisable turbulence, into the main venous pool.

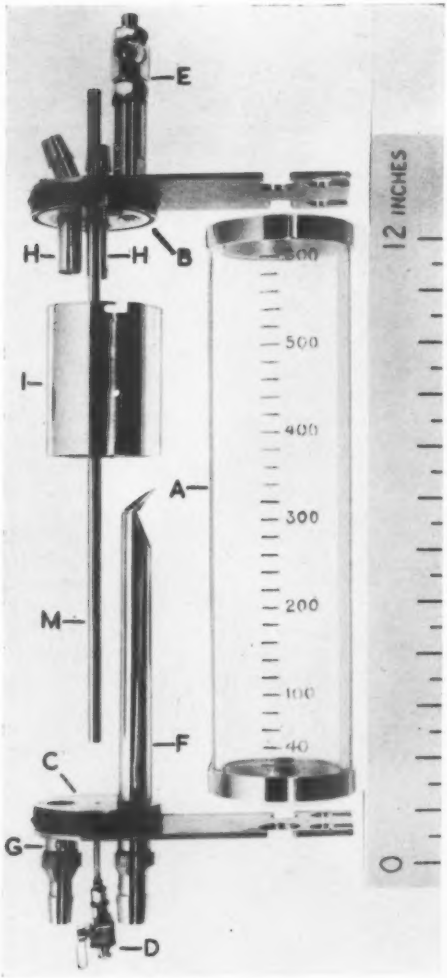

FIG. I. Venous reservoir partially dissembled. A — Perspex outer casing. B and C — End plates. D and E — Stopcocks. F — Venous inlet tube. G — Venous outlet (both F and G are fitted with screw-on nipples). H — Connectors for open heart return. I — Defoaming chamber. M — Priming tube.

PREPARATION AND OPERATION

After use the reservoir is completely disassembled and cleaned. The perspex casing is immersed in 20 per cent. sodium hydroxide solution at 65° F. for one hour and the stainless steel parts boiled in one per cent. sodium hydroxide for 10 minutes to remove the protein film (Bahnson, 1958). After thorough rinsing in tap water, the reservoir is reassembled and the inner surfaces coated with

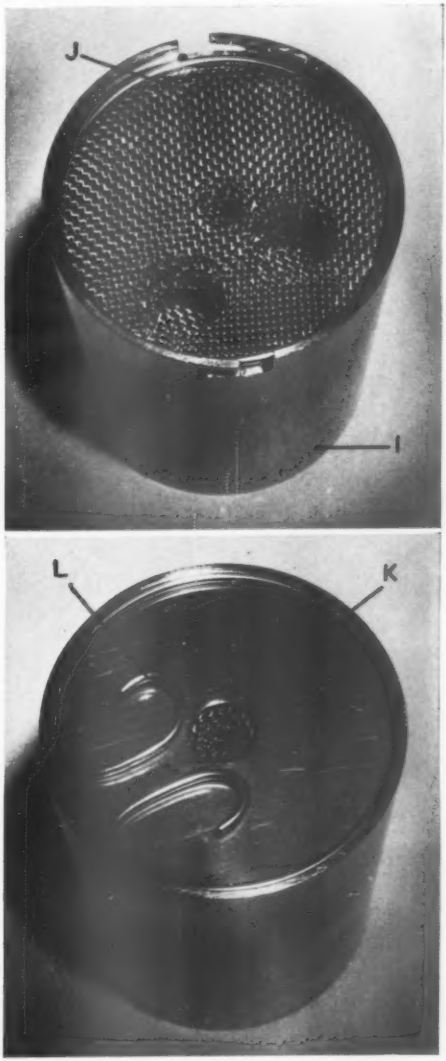

FIG. II. Defoaming chamber. Above: Top view. Below: Bottom view. I — Outer casing. J — Gauze discs: the two larger holes accommodate the connectors for open heart return, while the smaller central hole is for the priming tube (see text). K — Detachable base plate. L — Spring clip.

a fine film of Dow-Corning Antifoam A using petroleum ether as the vehicle. After a final rinse in pyrogen free distilled water the assembly is sterilized using 11 per cent. ethylene oxide gas in an inert diluent ("cryoxide").

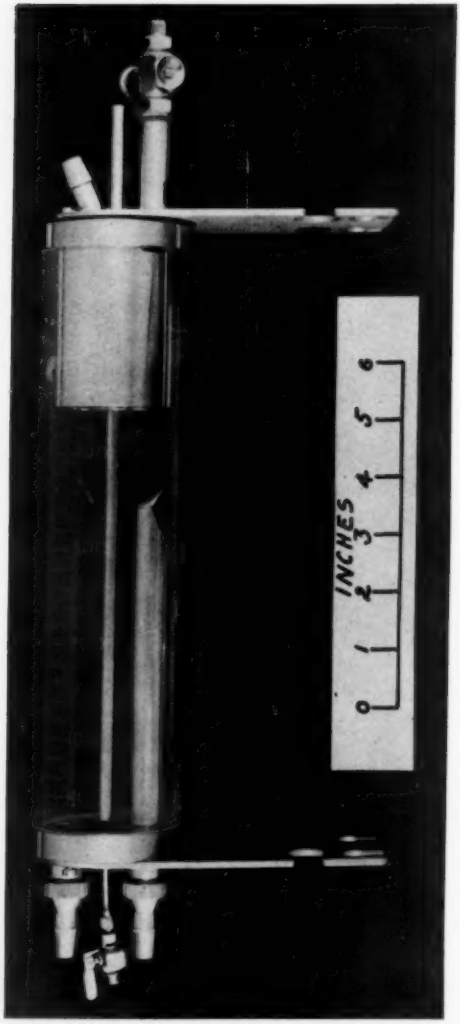

FIG. III. Venous reservoir assembled. The central priming tube can be seen to terminate just above the base plate of the reservoir. The flat stainless steel arms with slotted ends which project from either end are designed to hold the PVC tubing (see Fig. IV).

For this purpose the venous reservoir, together with all other parts of the perfusion circuit, are packed into a large canvas bag and then lowered into a vertical cylinder, approximately 6 cubic feet in capacity, which is provided with a gas-tight lid and warmed by steam piping to 140° F. A pump then draws a vacuum of 28 inches of mercury, after which the contents of one can of "cryoxide" are introduced into the chamber. After a minimum interval of twelve hours the vacuum is again drawn, the gas being pumped into the open air. Air is now admitted to the chamber through a sterilized glass-wool filter. Repeated bacteriological testing has shown that this system kills all organisms, including spores.

Following assembly, the heart-lung machine is primed with blood through the priming tube of the venous reservoir. At the start of perfusion the venous reservoir level is set approximately 10 inches below right atrial level. The stop cock (E) is initially closed to the atmosphere so that for the first few seconds of by-pass the venous pump exerts a negative pull on the venous lines and overcomes any inertia within them. The stop cock is thereafter opened to the atmosphere and the rate of perfusion monitored by the rate of venous return, the height of the reservoir being adjusted to maintain the venous pressure of the patient within a normal range. The open heart return is adjusted independently by varying the rate of the Sigmamotor pumps. Any additional blood required during the perfusion is added to the venous reservoir via the priming tube.

DISCUSSION

This venous reservoir has been in constant use in this unit for almost two years and has proved more than adequate to cope with an open heart return of 2 litres per minute and total flows of 4.5 litres per minute (Barratt-Boyes *et alii*, 1960). The venous blood level is completely free of turbulence and defoaming and filtering of the open heart return is highly efficient. One additional point does, however, require mention. When using a venous pump of high stroke volume the tubing leading from the venous reservoir to the venous pump should not be larger than $\frac{3}{8}$ inch internal diameter and should also be of adequate length (50 inches). If larger diameter tubing is used, particularly with the Melrose

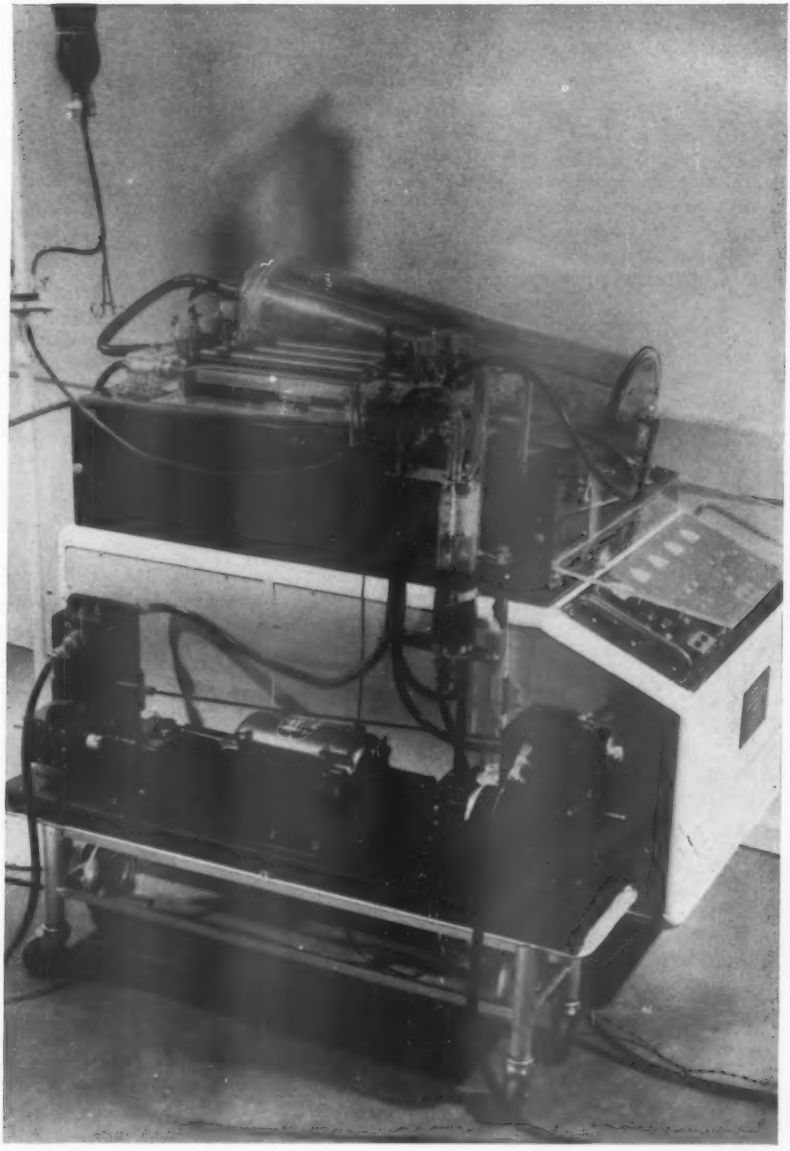

FIG. IV. The complete extracorporeal circuit using a Melrose-N.E.P. pump oxygenator system and Model T-6S Sigmamotor pumps for open heart return. These latter pumps are fitted with ½" I.D. latex tubing and give a flow range of 0-2000 ml./min. The venous reservoir is clipped to the adjustable slide which is fixed to the side of the machine. The handle for adjusting the height of the reservoir is within easy reach of the pump operator.

Pump (Melrose, 1955), turbulence occurs in the reservoir blood. With pumps of low stroke-volume this feature would be less important.

In our opinion, it is highly desirable to incorporate a venous blood level in a heart-lung by-pass circuit, for not only does this enable physiological monitoring of the perfusion by the rate of venous return but it also permits immediate detection of any reduction in flow from the patient and its prompt correction by adjustment of the venous lines or cannulae or by blood replacement. Valid objections to a venous reservoir are based solely on the complexity of incorporating the open heart return into the venous circuit. This objection is overcome by the present reservoir in which open heart blood is continuously and automatically added to the general venous pool. The Sigmamotor pumps controlling this return are manually adjusted according to the demands of the situation by an independent member of the team.

SUMMARY

A venous reservoir which acts as a receiver for both venous return and open heart return has been described.

The preparation and method of operation of the reservoir have been outlined and its advantages discussed.

ACKNOWLEDGEMENTS

We are greatly indebted to the designing and engineering staff of the Auckland Industrial Development Laboratories of the Department of Scientific and Industrial Research for their enthusiasm and skill.

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COMPLICATIONS AND DANGERS OF SIDE-TO-SIDE INTESTINAL ANASTOMOSIS*

By T. H. Ackland

Melbourne

RESTORATION of intestinal continuity after a bowel resection can sometimes be achieved with greater technical ease by a side-to-side, rather than by an end-to-end anastomosis. Such an instance occurs when there is a pronounced discrepancy in the diameters of the two bowel ends to be joined. The purpose of this paper is to emphasize that not only is side-to-side anastomosis physiologically unsound, but that serious, even fatal complications may follow its use.

The earliest report on this subject is that of Nicholas Senn, who in 1888, described the finding of stagnant hair, straw and other ingested material in side-to-side ileal anastomoses performed on dogs. On the other hand, Ashton and Baldy in 1891 and Küttner in 1896, advised the use of lateral anastomosis because of a very high mortality rate (40 to 50 per cent.) associated with end-to-end technique at that time; yet they acknowledged that stasis and pouching were likely to occur in the proximal blind end. In recent years there have been few advocates of this method but nevertheless side-to-side bowel anastomosis continues to be performed from time to time. It is especially likely to be used by inexperienced surgeons when conditions are difficult, for there is no doubt that it is a safe, simple and effective operative procedure. Physiological studies by Bayliss and Starling in 1899 and by Cannon and Murphy in 1906, led these authors to advise against the use of side-to-side anastomosis. They pointed out that, since food passes through the intestine by a circular contraction above the bolus and relaxation below, this sequence is rendered impossible when the circular muscle fibres have been divided and as a result, food is then pushed from above into the inactive part of the intestine. This in turn results in stasis and dilatation and, in addition, there is an absence of "milking" action in venules and lymphatic vessels.

From this time onwards, the literature contains numerous papers condemning side-to-side anastomosis (Pearce, 1934; Pickhardt, 1933; Heifetz and Senturia, 1950, and Barder and Humel, 1939). These writers cite numerous inimical sequelae, the intestinal changes most commonly observed being dilatation of the proximal blind end and ulceration near or at the anastomosis (Fig. I). Five writers refer to intestinal perforation (Black and McEachern, 1948; Estes and Holm, 1932; Gras, 1930; Ginzburg, Colp and Sussman, 1939, and Schumann, 1954) and there

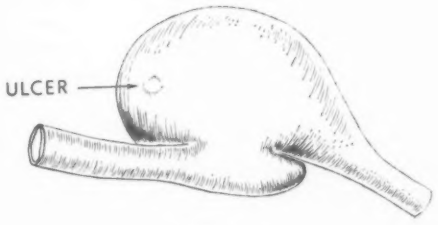

FIG. I.

seems little doubt that this is not an uncommon late complication. Apart from such a dramatic event however, a wide variety of symptoms may occur in these patients; colicky abdominal pain, tiredness, nausea, episodes of diarrhoea, distension, and loss of weight all being complaints which may be encountered. Weakness and tiredness are associated with anaemia, which is often of a macrocytic type. The most recent experimental work on the results of blind loop formation in animals is that of Cameron *et alii* (1949). These investigators have shown that the production of malnutrition and anaemia depends on the occurrence of stasis in a blind loop or sac, with resulting infection and that these symptoms may be abolished by resection of this part, or improved by the administration of antibiotics, folic acid, or liver injections.

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Many surgeons have doubtless seen cases with symptoms such as those described, in which, for one reason or another, it has been necessary to resect a side-to-side anastomosis and make a new end-to-end junction. There has nevertheless been too little recognition of the more serious complications of ulceration with perforation and still less of the possibility of ulceration with serious haemorrhage, although Clawson (1953) has recorded a case in which occult blood was found in the stools. This patient, who had a profound microcytic anaemia, was subsequently shown to have extensive marginal ulceration and it seems very likely that continued bleeding had occurred from the ulcerated area.

An extensive search of the literature has revealed no record of the occurrence of macroscopic or severe haemorrhage from this source. Yet it will be shown that this can occur and there is no doubt that this cause of chronic blood loss has not infrequently been overlooked in the past.

The writer's attention was first drawn to this matter at the Lahey Clinic, in 1954, on an occasion when Richard Cattell resected a lateral anastomosis in a patient who had been suffering from severe and repeated bowel haemorrhage. All investigations had been negative and the resection was performed with the confident expectation that, although the bowel showed no dilatation or other external abnormality, ulceration would be found. This was indeed the case, and an open vessel lay in the base of the ulcer. More recently, personal communications from Cattell and Warren indicate that at least 6 similar cases have been encountered at the Lahey Clinic.

In 1957, this subject was again brought to notice in a dramatic way, when a nursing sister at the Royal Melbourne Hospital suffered repeated bowel bleeding for which no cause could be found and, with a haemoglobin of 50 per cent., she one day fainted while on duty. A bowel resection with side-to-side anastomosis had been performed four years previously, and the final elucidation of this problem revealed that the source of bleeding was in fact similar chronic ulceration in the blind ileal end.

It is however clear that, since so many side-to-side anastomoses have been performed over the years, the incidence of haemorrhage from this source must be quite small. Its significance lies in the desirability of there being an awareness of this possibility and of the need to carry out an empirical resection when no other cause for bleeding can be found.

CASE REPORT

J.F., aged 26, a member of the nursing staff of the Royal Melbourne Hospital, in 1953 had a side-to-side ileotransverse colostomy after a right hemicolectomy performed for a non-specific inflammatory lesion of the ileocaecal region. An uneventful convalescence followed this operation, and she was quite well for two years, when, without other symptoms, she one day passed a little bright red blood after a bowel action. The next day there was nausea, followed by the passage of a large quantity of dark clotted blood. Her haemoglobin was 80 per cent. and at this stage it was considered probable that the bleeding had arisen in the haemorrhoidal area. She was then confined to bed for fourteen days, during which no further bleeding occurred, and examination of the faeces for occult blood was negative at the end of this period. A barium enema showed no abnormality.

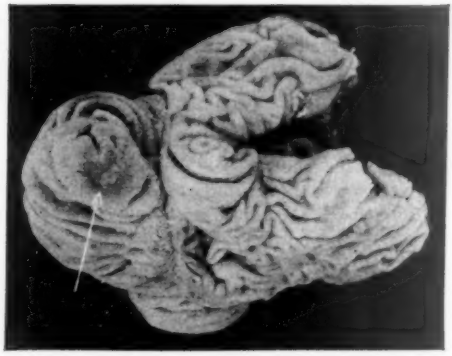

FIG. II. Resected specimen showing ulceration.

Two months later she complained of great tiredness, so that "she could not walk to the Nurses' Home after a meal," and was very dyspnoeic going upstairs. She fainted while on duty. Her haemoglobin was now found to be 52 per cent. and examination of faeces for occult blood was positive. Blood transfusion raised the haemoglobin level to 85 per cent. but within two days it had fallen to 65 per cent. A barium meal examination was normal, the anastomosis being seen clearly and a full blood examination showed no significant changes other than those associated with blood loss.

At this stage it was obvious that repeated bowel haemorrhages were likely to prove fatal if the cause could not be discovered and the diagnosis was made of ulceration associated with the lateral anastomosis. After further transfusion, laparotomy was performed and, although the junction was mobile, undilated,

and normal in appearance, it was resected and continuity restored by end-to-end technique. The specimen is shown in Fig. II. There was an ulcer 1.5 cms. in diameter in the blind end of the small intestine, with an eroded artery clearly visible in its base. Her convalescence after this operation was free from troubles and she remains well six years later.

SUMMARY

1. Strong evidence supports end-to-end anastomosis as the operation of choice for restoring bowel continuity.
2. Numerous inimical sequelae may result from the performance of lateral anastomosis, symptoms ranging from vague ill health with macrocytic anaemia, to intestinal perforation.
3. Haemorrhage from ulceration in the blind end of a lateral anastomosis is an unusual but possible complication of that procedure which has received no recognition in past papers.
4. Ulceration can occur in the absence of dilatation of the proximal blind end and may not be evident on inspection and palpation of the anastomosis at laparotomy.
5. Awareness of this possibility calls for empirical resection of the anastomosis when no other source of bleeding can be found.

ADDENDUM

Since this article was accepted for publication a further example of anastomotic ulceration has been encountered.

A female patient, aged 47 years, was admitted to the Royal Melbourne Hospital because of anaemia of five years duration, the nature of the anaemia being suggestive of chronic blood loss. Examination of the faeces for occult blood was positive, but both barium enema and barium meal disclosed no abnormality. The patient had had a bowel resection performed twelve years previously for a volvulus of the lower ileum. Laparotomy on 13th December, 1960, disclosed a side-to-side anastomosis with an area of induration in the proximal blind end. The anastomosis was resected and replaced by an end-to-end junction. Examination of the specimen revealed two ulcers, one ¼ inch in diameter corresponding to the area of induration, and another ½ inch in diameter situated on the line of the stoma.

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THE EFFECT OF ANTIBIOTICS IN INTESTINAL STRANGULATION*

AN EXPERIMENTAL STUDY

By E. A. Allcock

Department of Surgery, University of Melbourne

DURING the past twenty years emphasis has been laid on the correction of blood and electrolyte imbalance in the treatment of intestinal obstruction. More recently, however, considerable thought has been given to the importance of bacterial infection in the progress of intestinal strangulation.

It is possible to prolong life in the presence of intestinal strangulation for short periods only by the use of blood and electrolytes. In strangulation of the intestine, if death is not rapid and associated with oligaemia, it is almost always due to peritonitis. The treatment of intestinal strangulation is resection of the gangrenous bowel before infection can spread through its wall to the peritoneum.

Since infection is the overwhelming factor in intestinal strangulation, it should be possible to modify the course of the condition by the use of antibiotics. An animal experiment was, therefore, designed to study the effect of antibiotics on the natural history of intestinal strangulation.

Method

Mongrel dogs of either sex and between 9.5 and 14 kilogrammes were used. They were given anti-helminth treatment and fed on a normal kennel diet until the day of operation, when nothing was allowed by mouth.

After morphine pre-medication (15-30 mgm. I.M.) anaesthesia was induced with intravenous pentabarbitone (about 20-30 mgm./kg.). Skin preparation with ether soap and iodine was used and the peritoneum opened through a 5 cm. midline incision. A 30 cm. segment at the junction of the middle and distal thirds of the small bowel was selected and the veins were ligated and divided at the apex of the first arcade. The bowel continuity was maintained but at both ends of the loop the vessels were divided right up to the bowel wall. This ligation had to be most meticulous, for the preservation of a single small vein was found to be sufficient to prevent the onset of gangrene.

On the day following operation up to 500 ml. of normal saline (75 mEq. of sodium) were given intravenously together with 5 per cent. dextrose to replace fluid lost in the peritoneum. These were the maximal quantities of fluid used. No other intravenous therapy was given throughout the experiment.

Experimental groups

Group 1: Control — 10 animals.

Group 2: Five animals were treated by resection of the gangrenous bowel at varying periods post-operatively.

Group 3: Five animals were treated with 0.5 gm. of chlortetracycline into the bowel at operation, followed by 0.5 gm. b.d parenterally.

Group 4: Seven animals were operated on and the wounds were closed. One hour later 1,000 units of heparin were given intravenously and 10,000 units of heparin retard intramuscularly twice daily for five days. This ensured that the clotting time was maintained at a level of greater than one hour.

Group 5: A, B, C and D. Antibiotics were introduced into the bowel at operation. Either 0.5 gm. or 1.0 gm. of the drug was injected in solution into the bowel lumen proximal to the strangulated segment. Alternatively, a small incision was made into the bowel lumen distal to the site of thrombosis and intact capsules were inserted and milked so that they rested proximal to the thrombosed segment. This was done to avoid injury to the bowel wall in an area where distension was expected to occur. Post-operatively, 0.5 gm. of antibiotic was given in water either by mouth or stomach tube twice daily for 5 days.

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OBSERVATIONS

The control group

Immediately after ligation of the veins a haemorrhagic swelling developed in the mesentery and bowel walls. This increased for some hours, the colour of the segment changing from dusky cyanosis to black. Concurrently, a blood-stained peritoneal exudate developed. This was observed very early as the exudate could be seen within minutes of completing the ligation.

FIG. I. The strangulated loop at autopsy. The veins draining this 30 cm. segment of small bowel were ligated and divided 40 hours previously. The loop is gangrenous throughout and shows an area of definite softening (top of figure).

Recovery from anaesthesia was always rapid and complete and the animal seemed to be satisfactory for some hours. There was frequently melaena, and occasionally haematemesis was observed. The animals appeared to be thirsty but could not tolerate oral fluids. In general, the animals were apathetic until a rigor, vomiting and respiratory embarrassment developed suddenly and death occurred within seventy-two hours of the operation.

Re-examination of the loops six, eighteen, twenty-four and thirty hours post-operatively showed that between eighteen and thirty hours after operation the bowel became black and lustreless and the peritoneal fluid dark, turbid and offensive. At autopsy the bowel was always engorged and gangrenous but on only two occasions had perforation of the segment occurred (Fig. I). Ten controls were prepared, of which 9 were satisfactory. In one animal failure to ligate a small venous channel in the mesentery near the centre of the loop allowed the bowel to survive.

Post-operatively a leucocytosis developed very rapidly but the counts were not significantly different from those in the treated groups. Neither the presence of a leucocytosis nor its degree were of any significance in assessing the severity of the intestinal lesion. The greatest rise in the leucocyte count occurred between twenty-four and forty-eight hours (Fig. II). The subsequent changes were more variable for, although

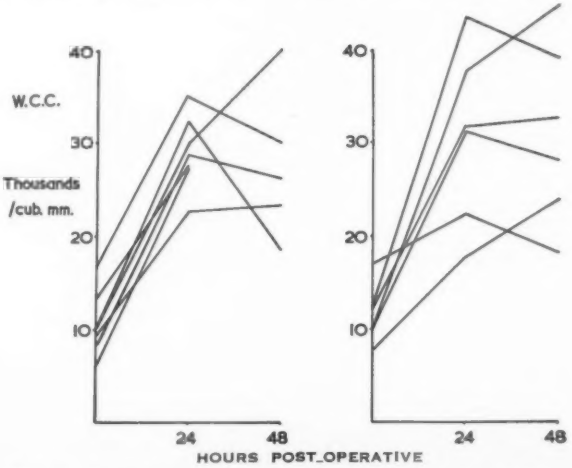

FIG. II. Leucocyte counts in control group (left) and protected group (right) 24 to 48 hours after strangulation.

some continued to rise, others showed a tendency to fall. In the peritoneal fluid prodigious rises in the white cell count occurred, 100,000 leucocytes per c.mm. being not uncommon. When frank pus was present in the peritoneum degeneration of the white cells made differential counts impossible.

Bacteriology of bowel lumen

Quantitative assessment of the intestinal flora is difficult. Many techniques have been tried but, since they commonly rely upon an indwelling tube to secure the specimens, are invalid because it is known now that the presence of a tube in the bowel will precipitate the development of a flora of faecal type within a very few hours (Anderson and Langford, 1958). The technique of direct sampling (Cregan and Hayward, 1953) has proved adequate for obtaining uncontaminated specimens. It does, however, demand that the abdomen be opened and the bowel exposed, so that washings may be taken from the lumen. In man there is a great increase in the number of organisms in the bowel proximal to an obstruction (Allcock and Bishop, 1959). Similarly, in the experimental animal it was possible to demonstrate a marked increase in the numbers of organisms above the obstruction with little change distally. Samples were examined from a number of animals. All showed a similar picture of which 9B was typical.

TABLE 1

CONTROL GROUP: FLORA OF PERITONEAL EXUDATE AT AUTOPSY

No.	*Result*	*Peritoneal fluid*
1	Died 18 hours	*No autopsy*
7b	Sacrificed 24 hours	*B. coli., Str. viridans, Cl. welchii*
8b	Sacrificed 24 hours	*B. coli., Str. viridans, Cl. welchii*
9b	Died 40 hours	*Staph. albus, Str. faecalis, Cl. welchii*
10a	Died 30 hours	*No autopsy*
10b	Died 60 hours	*B. coli., Cl. welchii*
16a	Died 23 hours	*B. coli., B. friedlanderi, Cl. welchii*
17	Died 26 hours	*Staph. albus, Cl. welchii, Diphtheroids*
18c	Died 44 hours	*B. coli., Str. viridans*
9d	Survived	

Group 2: Treatment by resection

Treatment by resection was applied to a group of 5 animals. The resection was done using aseptic technique and an end-to-end anastomosis was performed. These animals required careful and prolonged intravenous therapy before recovery occurred. The character of the peritoneal exudate at the time of resection is noted in Table 2.

TABLE 2

RESULTS OF RESECTION OF STRANGULATED LOOP

No.	*Time of resection*	*Peritoneal fluid*	*Result*
11a	18 hours	Sterile	Survived
11b	24 hours	Sterile	Survived
12a	24 hours	Sterile	Survived
13	40 hours	Infected	Survived
12b	48 hours	Infected	Died

At operation: Small numbers of coliforms. *Str. faecalis* was present in greatly increased numbers.

Twenty-four hours: *Coliform. Strep. faecalis and Cl. welchii* were present in greatly increased numbers.

Forty hours: The same organisms were present in profusion with gross infection of the peritoneal exudate. The bowel distal to the obstruction yielded a light growth of the same organisms.

In cases where the cultures were taken from the bowel twenty-four and forty-eight hours after operation in animals protected by antibiotics, the growth was remarkably less. In some of the specimens organisms were only found with difficulty in smears and cultures yielded a light growth of one or two organisms which appeared to be very resistant to the antibiotic used. The differences were quantitative rather than qualitative.

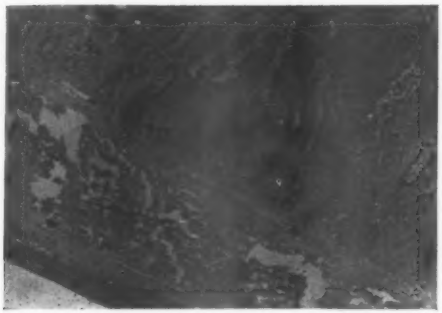

FIG. III Control at 24 hours. A haemorrhagic infarction of the mucosa has occurred, with necrosis of most of the glandular elements down to the submucosa. The submucosa is also engorged and becoming disorganized.

Specimens were taken from 20 preparations and cultured under aerobic and anaerobic conditions on desoxycholate and blood agar media. The bacteria identified constituted only a few of the vast flora present. *Cl. welchii* was found on 18 occasions, *coliforms* 18, *Strep. faecalis* 16, while *B. paracoli, proteus, sp. bacteroides, B. friedlanderi* were less frequently identified.

Bacteriology of the peritoneal exudate

The peritoneal exudate was obtained at autopsy at open operation or by paracentesis abdominis and cultured under aerobic and anaerobic conditions. In the control group it was frequently possible to see organisms in direct smears in 24-hour specimens, together with leucocytes in all stages of degeneration. In the groups treated with antibiotics into the bowel lumen there were striking differences. Of 12 investigated the peritoneal fluid was sterile in 8 and only very lightly infected in the other cases.

Histology of the strangulated bowel

Within the first five hours little difference was noted between the protected and control groups. By the end of twelve hours an extensive necrosis had occurred in the superficial parts of the intestinal villi. This was more obvious and more advanced in the control animals in which at twenty-four hours the bowel wall was gangrenous (Fig. III) and micro-organisms could be demonstrated in the tissues by means of Gram's stain (Fig. IV). In animals protected by antibiotics

FIG. IV. High-power photomicrograph showing gram positive rods in the submucosa.

there was destruction of the superficial parts of the villi only with preservation of the deepest cells in almost all cases (Fig. V). Submucosal swelling and extravasation of blood cells were a very prominent feature but the layers of the bowel wall were easily recognizable and clearly viable. The process of recovery occurred slowly with regeneration of the mucosa and resolution of the engorgement. It took two to three weeks before the process of healing was complete.

COMMENTARY

The history of abdominal surgery has followed the fortunes of the struggle with infection more than any other factor. The great surgeons of the 19th century were well aware of this and developed techniques such as the lumbar colostomy to avoid at all costs soiling the general peritoneal cavity. Operations on

the abdominal viscera were hazardous in the extreme and even Astley Cooper (1839) counselled a conservative approach to strangulated herniae although equally he believed that, should this fail, operation was preferable to delay.

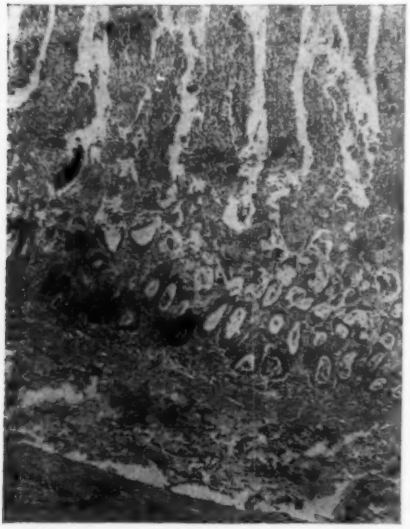

FIG. V. Section of small intestine within the strangulated loop protected with intraluminal chlortetracycline at 24 hours. There is necrosis of the villous layer of the mucosa with preservation of the depths of the crypts. The submucosa is engorged by haemorrhagic oedema but the vitality of the structures is preserved and the muscularis appears relatively normal.

Opinion changed rapidly in the 20th century. The bacterial nature of infection was now understood and the principles of surgical technique and management were crystallizing. The kindred problems of infection and dehydration, however, continued to cause concern and many of the analyses of results were witness to this. Wilkie (1913, 1922) reporting on experimental intestinal strangulation concluded that, in animals which died soon after the strangulation, toxaemia was of no consequence. On the other hand, in those which died after the lapse of 24 hours peritonitis was probably the ultimate cause of death.

In 1924, Foster and Hausler confirmed and expanded Wilkie's observations by underlining this fundamental difference between the long and short loop strangulations in the experimental animal. In the dog they showed that venous occlusion over a length of 40 cm. or more of small bowel was followed by a fall in blood pressure with a rising pulse rate and death in shock. When strangulation was induced in 25 cm. loops there was a small fall in blood pressure during the first six hours post-operatively from 140 mm. systolic to 110 mm. systolic with an associated rise in pulse rate. These animals continued in this state until shortly before death when peritonitis precipitated a profound irreversible shock. These results were confirmed by Holt (1934), who attributed the early death of long loop strangulations to oligaemia. In 1936 Knight and Slome showed that, in addition to oligaemia, a depressor substance could be demonstrated in the peritoneal exudate, mesenteric venous blood, and lymph from the thoracic duct. Aird and Henderson (1937) suggested that histamine was the agent responsible for this effect but Maycock (1938) recalling the original work of Sir Henry Dale 1920) pointed out that the actions of histamine are greatly modified by anaesthesia. *Cl. welchii* toxin has been implicated by Williams (1926) and McIver, White and Lawson (1929) as the depressor agent and recently the observations of Lillehei (1957, 1958) on selective hypotension of the mesenteric arterial system have reopened this question of "intestinal shock" in a most fascinating way though Wiggers (1941) had demonstrated a similar phenomenon.

In the presence of extensive strangulation of the bowel, intravenous fluids have been shown to prolong life. With shorter loops the factors associated with infection become more obvious and efforts were made to prolong life in these animals. Foster and Hausler (1924) enclosed the strangulated loop in a rubber bag and were able to prolong life. Holt (1934) did a similar experiment but allowed the balloon to drain externally. Death followed, though it was delayed to some extent. Similarly aspiration of the bowel proximal to the obstruction did not materially alter the outcome. These observations were most important because they showed that the bowel contents were of little significance when compared with the effects of the gangrenous intestine, though Murphy and Vincent (1911), Murphy and Brooks (1915) and Dragstedt, McClintoch and Chase (1919) had shown that bacteria were necessary in the bowel lumen before the lethal

effect of venous strangulation occurred, the bacteria potentiating the vascular embarrassment. The conclusion to be drawn is that with strangulation the bowel wall becomes a permeable culture medium and allows micro-organisms to infect the peritoneum. Early excision of the strangulated loop before the fatal overwhelming peritonitis occurred would, of course, avert this outcome.

The development of antibiotics has provided another method to test these theories for, if the bowel lumen can be rendered sterile by the use of antibiotics, a significant increase in the survival of animals subjected to intestinal strangulation should be shown to occur (Nemir, Hawthorne, Cohn and Drabkin, 1949; Pott and McClure, 1950; Rabinovici and Fine, 1951; Cohn, Gelb and Hawthorne, 1953). The immediate post-operative course is not significantly different from the unprotected animal. During the ensuing hours, however, marked differences may be noted. If vomiting occurs blood is seldom found and never in large quantities. The dog will defaecate two or three times but there is seldom a large quantity of blood in the faeces. This is in marked contrast to the control animals, where the mucosa sloughs relatively early and a haemorrhagic exudate collects within the lumen as well as in the peritoneum.

The peritoneal exudate continues to collect for about 48 hours but not in large quantity. It remains pink and inoffensive, though it may be possible to isolate occasional organisms from it on culture. In animals where a heavy infection was found in the peritoneal exudate the prognosis was grave despite the presence of antibiotics in the bowel lumen. Death invariably followed and, at autopsy, extensive necrosis of the bowel wall identical to that found in the unprotected animals was present.

The reason for survival in the animals treated by intestinal antibiotics therapy is almost entirely a local one. With the sterility of the bowel assured the mucosa which is embarrassed by ligation of the major part of its venous drainage is not submitted to the destructive effect of the infection normally present. If the antibiotics are administered parenterally as in Group 3 (Table 3) the results are not nearly as satisfactory and show very little difference from those of the control group.

TABLE 3

GENERAL SUMMARY OF RESULTS

Venous strangulation 30 cm. segments

Group	*Treatment*	*Number treated*	*Number survived*
1	Control	10	1
3	Chlortetracycline (parenterally)	5	2
4	Heparin	7	3
5A	Chlortetracycline	5	4
5B	Oxytetracycline	4	4
5C	Neomycin	8	5
5D	Chloramphenicol	6	5

It was thought that heparin would prevent propagation of thrombosis and thereby allow the collateral circulation to develop. In Group 4 the animals were treated with heparin to maintain a clotting time of more than sixty minutes. The increased expectation of survival is not significant.

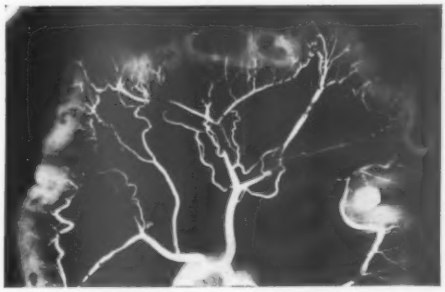

FIG. VI. Mesenteric venogram of a recovered loop at 6 weeks. The formation of many new tortuous channels in the mesentery bridging the defects caused by ligation of the veins at the apices of the arcades is demonstrated.

The recovery of the venous drainage of the loop is very interesting. The dilatation of the vessels at the edges of the segment becomes obvious very quickly and should the animal survive many new channels develop to bridge the gaps between the ends of the divided veins (Fig. VI). Concurrently a

vigorous reaction develops in the structures surrounding the embarrassed loop. Adhesions form between other coils of bowel, parietal peritoneum and the loop. Although the strangulated intestine attracts the omentum, the size of the lesion is too great to allow the area to be walled off completely. The animal in consequence gains no degree of protection from the omentum. Histologically, in the animals that recovered, the haemorrhagic oedema in the sub-peritoneal layer of the viscera resolved more quickly than the swelling in the submucosa which persisted for many days longer. With healing there is some contraction in the length of the segment of the bowel but its motility and histological features returned to normal.

CONCLUSION

The value of high concentrations of broad spectrum antibiotics in the lumen of the bowel of animals subjected to venous strangulation seems quite clear. The period when this is most effective is during the first twenty-four hours following the strangulation. In the presence of infection gangrene of the mucosa occurs with rapid penetration of the outer layers of the bowel wall by organisms causing peritonitis and death. A high concentration of antibiotic within the bowel allows time for an adequate circulation to be restored to the embarrassed loop. Parenteral antibiotics are not as effective.

Heparin, because it inhibits intravascular clotting, might be expected to minimize the severity of the procedure and allow small anastomotic channels to remain patent. The results of this form of treatment, though better than the controls, were not as good as those obtained with antibiotics. Excessive blood loss did not account for the difference in results.

The pathology of the condition is discussed and the bacteriological findings recorded.

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NECROTIZING ENTERITIS*

By Rowan Webb

Melbourne

NECROTIZING enteritis is an acute, destructive lesion of the intestine, characterized by widespread necrosis of the mucosa, the formation of "pseudomembranes," and rapid accumulation of fluid in the lumen, resulting in profound circulatory collapse.

The clinical course has been likened to that of Asiatic cholera. Frequent watery stools are passed, and in most cases, the shock is very resistant to treatment, death following within a few hours.

The condition is also known by a number of synonyms, especially "pseudomembranous" and "diphtheritic" entero-colitis.

It is not necessarily a specific disease, as it occurs from time to time as a terminal phenomenon in such conditions as renal failure, peritonitis, Addison's disease, gross anaemia, and malignant disease. It has been described as a cause of death in septicaemia, and advanced cardiac failure. Sporadic and epidemic forms, almost certainly infective, have been reported, and it is now well known that drug-resistant staphylococci may cause a destructive and often fatal entero-colitis when other organisms have been eliminated from the bowel by chemotherapy.

Of particular interest to surgeons is a catastrophic type of necrotizing enteritis, fortunately rare, which occurs unexpectedly within a few days of an abdominal operation. The majority of cases occur two or three days after operation, although delays of over a fortnight have been reported. A rise in pulse rate and fall in blood pressure are usually the earliest signs, along with some tumidity of the abdomen. Profuse watery diarrhoea follows, with the passage of "pseudomembranes." Offensive vomiting may also occur, but is less common than diarrhoea, and does not persist. The outcome in the majority of reported cases has been fatal, often despite energetic resuscitative therapy.

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Because of its rarity, many surgeons may be unfamiliar with the condition, and with the need for massive and early intravenous therapy. For this reason, the history of such a case is presented, with some impressions gained from a review of the pertinent literature.

FIG. I. Ileal cast passed by a patient with necrotizing enteritis. (Mr. G. Pestell's case.)

Case History

J.G.L., an otherwise healthy man, aged 46 years, presented on 12th October, 1953, with clinical signs of acute appendicitis. He gave a history of mild diarrhoea and fever during the preceding two days. Immediate operation was performed, and a gangrenous appendix removed without difficulty. There was no evidence of spread of infection at operation, and an uneventful convalescence was anticipated. His condition was good on the following day and some bowel sounds were heard, but at 1.00 a.m. on the second post-operative day some restlessness was observed by the nursing staff. At 6.00 a.m. he began

to vomit and 600 ml. of offensive fluid were aspirated from the stomach. Three copious fluid stools were passed into the bed, the pulse rose to 120 per minute, the blood pressure fell to 100 mm. of mercury, and the haemoglobin concentration was found to be 140 per cent. The patient was collapsed and cyanosed. His condition improved to some extent with very energetic intravenous therapy (6½ litres on the first day) and the amount aspirated from the stomach became less. Blood culture, stool culture, and E.C.G. tests were done at the onset of collapse, and all proved negative. Penicillin and streptomycin were given as an infective complication was feared, although no blood or pus was found in the stool at this stage. Diarrhoea persisted, and on the fourth post-operative day a cast of ileal mucosa was passed. Culture of this material was negative. The abdomen was tumid but soft throughout and occasional bowel sounds could always be heard.

On the seventh post-operative day jaundice appeared and reached a maximum in about a week, fading gradually over a period of about one month. Bile pigment was present in the stools.

Soon after the appearance of jaundice he was transferred to the care of Dr. Ian Wood in the Clinical Research Unit at the Royal Melbourne Hospital. His condition was maintained fairly well on intravenous therapy, but no lasting improvement was achieved by the exhibition of further antibiotic drugs and cortisone. Laparotomy on 19th November, 1953, revealed that bleeding was taking place in and beyond the jejunum, and that the small intestine was slightly thickened. There was no evidence of any other intra-abdominal complication. Diarrhoea, bleeding from the bowel (requiring a total of 54 litres of blood), and malabsorption of food progressively undermined his condition, and death occurred on 17th December, 1953, sixty-six days after his original operation.

Post-mortem findings

Gross emaciation and decubitus ulceration were present.

The duodenum and proximal 3 metres of small intestine were normal. In the next 1.5 metres of intestine the mucosa was roughened with loss of regularity of rugae, and in the lower portion were patches devoid of villi, and apparently covered by smooth mucosa. The serous surface in these areas was injected. The remainder of the ileum showed patchy smooth areas alternating with areas of apparently normal mucosa, which in parts appeared heaped up and possibly regenerated. In several areas the mucosa was excoriated.

The colon appeared normal macroscopically, and the liver appeared slightly darker than normal. Microscopic examination revealed that large areas of jejunum were denuded of epithelium, which was replaced by exudate and granulation tissue. There was some evidence of epithelial regeneration. Early biliary cirrhosis was found in the liver.

This case is unusual in that the patient survived for some weeks, and therefore the pathological changes of the first few days had long since been replaced by those of subacute ulceration and attempts at healing.

MORBID ANATOMY

From autopsy reports on acute cases, it appears that necrotizing enteritis is usually patchy in distribution, and may occur anywhere from the lower oesophagus to the rectum. Penner (1948) describes early lesions which start as small foci of congestion and thickening which coalesce. Haemorrhagic phenomena may be seen, and the mucosa becomes shaggy and separates. Separation of these patches of mucosa may expose the muscle, but perforation is uncommon. The affected segments become moderately congested, and distended with large volumes of fluid.

The microscopic features have no special characteristics. There is oedema of the submucosa, with dilatation of venules and capillaries, followed by haemorrhage in this plane. Surface necrosis occurs, and the dead tissue, mixed with fibrin, forms a membrane.

Most fatalities take place at an early stage and it is presumed that in those who recover, healing of the denuded areas will be by second intention. The patient reported above remained alive in the presence of activity of the condition for an exceptional period, and any attempt at healing was by granulation tissue rather than by epithelium. It is to be expected that a patient surviving an extensive lesion would suffer from considerable loss of the power of absorption of food and fluid.

AETIOLOGY

Although the condition has been recognized at least since Finney described a case following gastro-enterostomy in 1893, the aetiology is still poorly understood.

Certain general observations have been made. Hultborn (1956) observed that poor nutrition was a factor in several of his cases, and that operations on the stomach were most commonly complicated in this way. On the

other hand, Pettet, Baggenstoss and colleagues (1954) reporting 94 cases from the Mayo Clinic found that in this series, nearly half the patients had had operations on the colon. They too reported poor pre-operative condition in some of their patients, and it was suggested that intestinal obstruction was an important factor.

Penner and Druckerman (1948) drew attention to shock as a possible cause, and postulated that this might induce an intense compensatory vasospasm in the submucosa, followed by superficial necrosis. However, shock has not been present in many cases reported by other writers (Dixon and Weismann, 1948; Williams and Pullan, 1953), or in the case described above.

The clinical features of post-operative necrotizing enteritis are so similar to many proven cases of fulminating infective enteritis that it is difficult to exclude infection as a possible cause. It is true that the classical macroscopic and microscopic features of infection may be lacking (Bruce, 1954) and that efforts to culture organisms are usually fruitless. It is possible that in the past this has often been due to the use of unsuitable media and techniques. Unless particularly advised beforehand the pathologist may use a medium with substances added to exclude staphylococci and anaerobes.

The patient has all the appearances of acute intestinal poisoning, whether by products of his own metabolism, or those of a micro-organism. An epidemic or necrotizing enteritis unconnected with surgery was reported in Europe in 1946 (Fick, 1949), and Zeissler and Rassfeld-Sternberg (1949) reported cases due to *Clostridium Welchii* type F, a type not normally found in the intestine. The spores of this organism are highly resistant — they withstand boiling for four hours — and these authors, using the B toxin, produced lesions of necrotizing enteritis in guinea pigs.

Rob (1954), in a discussion at the Royal Society of Medicine, stated that in six cases he had been able to recover staphylococci by culture of the gastric aspirate, and that favourable results followed treatment by large oral doses of penicillin.

Prohaska *et alii* (1954) reported improved results after treatment with A.C.T.H., and deduced that infection must have been absent, otherwise this hormone would have aggravated it. An alternative interpretation is that A.C.T.H. ameliorated the phenomena of inflammation, rather than its cause.

One must conclude that although many suggestive observations have been made, little has yet been added to Penner's generalization that this appears to be a "non-specific reaction to a variety of stimuli." Treatment must still be planned largely along general and non-specific lines.

Differential diagnosis is difficult, and is perhaps best postponed until urgent resuscitative measures have been instituted. Sudden circulatory collapse within a few days of operation raises the possibility of a myocardial or mesenteric infarct, peritonitis or paralytic ileus, and the onset of copious diarrhoea demands stool culture to detect cases of enteritis due to antibiotic resistant staphylococci.

TREATMENT

Until now this has been largely empirical — vigorous intravenous therapy to counter shock and fluid loss, and the giving of antibiotics against the possibility of an infective complication.

It is difficult to make precise recommendations about the prevention and management of such cases in the future.

Of first importance is the awareness of the existence of the condition, and the possibility of its occurrence, particularly after operations on the alimentary tract.

Patients with gross cardiac or renal impairment, poor nutrition and anaemia, intestinal obstruction and those undergoing shocking procedures have an increased liability to the condition, but these are surely the indications for the most scrupulous care in any case. The most devastating cases of necrotizing enteritis are likely to appear "out of the blue."

Intravenous therapy is required at a rate and in amounts which are at first alarming, and it is of interest that a conviction of

murder by stabbing of the abdomen was recently contested in England on the grounds that the victim died not of his wounds, but of inordinate amounts of intravenous fluid *(Brit. med. J., 1956)*. It was demonstrated from the post-mortem findings that necrotizing enteritis was present as a complication of the injury, and that massive intravenous therapy was therefore absolutely in order.

Antibiotic therapy should probably be given, as the condition may yet prove to be an infection, and there must be some risk of secondary infection. Cortisone may have a valuable part to play in treatment, but to date little evidence of this has accumulated. The early results of Prohaska suggest that A.C.T.H. or cortisone should be given even if only on empirical grounds.

SUMMARY

The clinical features and morbid anatomy of necrotizing enteritis are described.

The history of a fatal case following appendicectomy is presented.

The several theories of aetiology of this condition are discussed.

An outline of treatment is given.

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INJURIES OF THE ANTERIOR INFERIOR TIBIO-FIBULAR LIGAMENT*

By M. B. MENELAUS

Birmingham Accident Hospital

COMPLETE ruptures of the anterior inferior tibio-fibular ligament are followed by persistent pain if inadequately treated, as has been stressed by Bonnin (1950). The purpose of this article is to clarify the nature of the injuries to which this ligament is liable and their diagnosis and treatment.

ture of the ligament without fracture of the fibula and their associated physical signs which have not been fully described in the literature on the subject. The explanation for many of these clinical features was apparent as a result of the findings at operation on 3 patients suffering from rupture of this

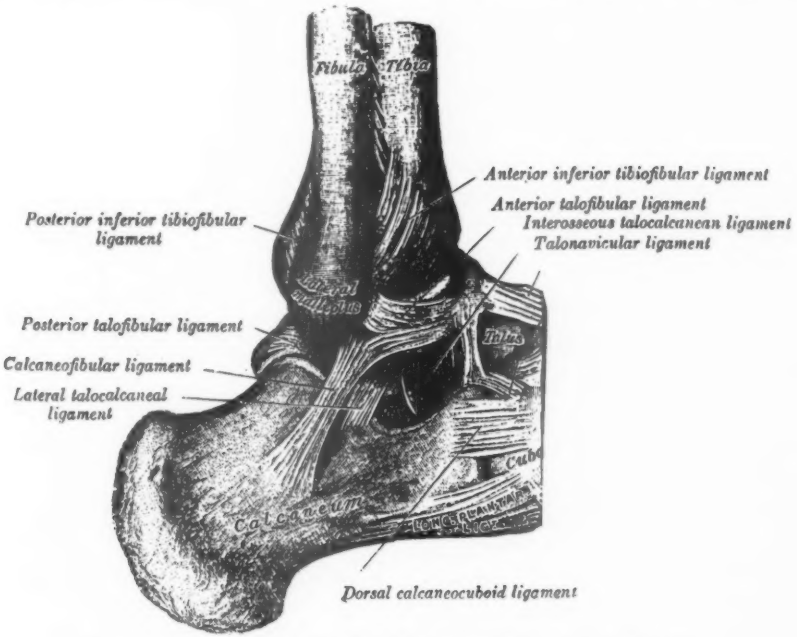

FIG. I. The extent of the anterior inferior tibio-fibular ligament is shown. (From Gray's *Anatomy*.)

The anterior inferior tibio-fibular ligament is injured by external rotational force. The ligament may suffer tearing of some of its fibres (referred to as a sprain) or it may rupture. Further external rotation violence results in a spiral fracture of the fibula. Attention will be confined to sprain and rupligament. In these patients, on whom internal fixation of the disrupted syndesmosis was secured with an oblique screw, a constant pattern of injury was found and, although the number of cases so treated has been small, these cases are of sufficient interest to be considered in detail. Furthermore the operative findings and the results of operation in these cases suggest that this form of treat-

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ment should be employed more frequently in cases of rupture of the anterior inferior tibio-fibular ligament and that it may provide the only form of treatment by which complete restoration of the normal anatomy can be achieved.

THE MECHANISM AND ANATOMY OF INJURY

The force that produces partial or complete rupture of the anterior inferior tibio-fibular ligament is generally thought to be forcible internal rotation of the leg with the foot

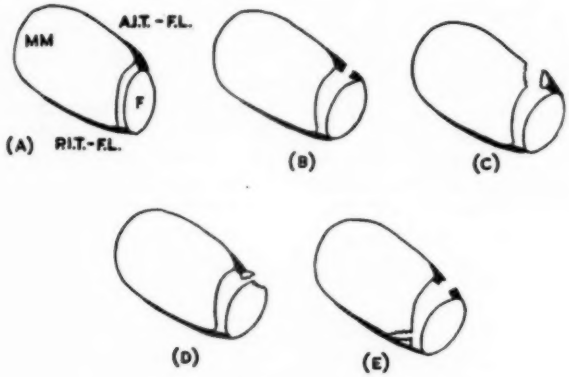


FIG. II. Diagrammatic representation of the mortice.
The normal anatomy is represented in A.
MM — position of medial malleolus.
F — lower end of fibula.
A.I.T.-F.L. — anterior inferior tibio-fibular ligament.
P.I.T.-F.L. — posterior inferior tibio-fibular ligament.
The first stage of external rotation injury may rupture the anterior inferior tibio fibular ligament (B), may avulse a fragment of bone from the tibia (C) (see also Fig. VI), or may avulse a fragment from the fibula (D) (see also Fig. VII).
Further external rotation force may result in fracture of the posterior lip of the fibular groove of the tibia (E). The fragment is frequently larger than that illustrated. Even when this is so the extensive attachment of the posterior inferior tibio-fibular ligament ensures that internal rotation of the fibula will reduce this fracture.

THE ANTERIOR INFERIOR TIBIO-FIBULAR LIGAMENT

The anterior inferior tibio-fibular ligament (Fig. I) is the stoutest (up to 5 mm. in thickness) and strongest of the three ligaments of the inferior tibio-fibular syndesmosis. It passes downwards and laterally from the lower 2 cm. of the anterior surface of the tibia where it blends with the periosteum and from the anterior lip and tubercle of the fibular groove of the tibia. From these attachments it extends as an oblique band to the anterior of the 2 tubercles on the medial aspect of the lower end of the fibula and the anterior surface of the lateral malleolus. The ligament becomes taut on dorsiflexion and external rotation of the foot and when the weight-bearing foot is forcibly inverted.

firmly planted on the ground, so that the mortice is internally rotated on the fixed talus and its fibular component is subjected to strain tending to separate it from the tibial component. To conform with the usual terminology it is an external rotation injury, the talus being externally rotated relative to the mortice. The same damage can be caused by inversion of the foot while under load and this is the mechanism of injury in patients with the physical signs of damage to the lateral ligaments of the ankle joint and the anterior inferior tibio-fibular ligament.

Ashurst and Bromer (1922) state that "it is easily seen in the prepared specimen that in all movements of the foot there is greater strain on the anterior than on the posterior inferior tibio-fibular ligament; and that if the

anterior ligament alone is divided, a separation of the fibula from the tibia to the extent of about one centimetre becomes possible anteriorly, the fibula still being attached by the interosseus ligament and the posterior tibio-fibular ligament. This degree of separation is sufficient to constitute a diastasis; less degrees with incomplete rupture of the anterior tibio-fibular ligament, and therefore without separation constitute a sprain." Thus with a small external rotation force there is a rupture of some fibres of the anterior inferior tibio-fibular ligament. With further force the ligament ruptures (Fig. IIb), or pulls off a flake of bone at its attachment to the anterior lip of the fibular groove of the tibia (Fig. IIc). This is presumably the fragment somewhat indefinitely described by Tillaux (1872). Rarely, a fragment of bone is avulsed from the fibula at the site of attachment of the ligament to that bone (Fig. IId).

FIG. III. Case 1. P.B., age 22. There is widening of the inferior tibio-fibular joint and tilting of the talus. As is frequently the case these features are not marked. At operation a flake of tibia was found to have been avulsed by the anterior inferior tibio-fibular ligament and although it cannot be seen in this radiograph it is well shown in the case illustrated in Fig. VI.

Generally, external rotation of sufficient violence to rupture the anterior inferior tibio-fibular ligament causes rupture of the short fibres of the deltoid ligament. Hansen (1942) has suggested that the extent of the injury to the deltoid ligament depends on the position of the foot at the moment of injury. He has described a pronation-eversion injury in which the foot is in the prone position, with the outer edge of the foot raised in relation to the inner and therefore with the deltoid ligament tight at the moment of injury. In this position he showed that the first effect of eversion (external rotation) was rupture of the deltoid legament or avulsion of the medial malleolus. Greater force produced rupture of the anterior inferior tibio-fibular ligament. On the other hand, if the foot was supinated

(a) (b) (c)

FIG. IV. Case 2. P.F., age 25.

(a) There is obvious widening of the interval between the medial malleolus and talus.
(b) The effect of external rotation.
(c) Reduction of the dislocation by internal rotation.

and the deltoid ligament therefore relaxed, he found that the first effect of outward rotation of the talus was rupture of the anterior inferior tibio-fibular ligament; only after enough force had been applied to produce a helical fracture of the fibula, did rupture of the deltoid ligament occur.

Greater violence first tears the interosseous tibio-fibular ligament and then may result in a separation of the posterior tibial tubercle. Because the long posterior fibres of the posterior tibio-fibular ligament are still intact (Fig. IIe), internal rotation of the fibula will reduce the displacement of this fragment.

In the 3 cases undergoing surgery the extensor retinaculum was found to be intact as indeed it is in fracture dislocations of the ankle due to external rotation violence.

CLINICAL FEATURES

It is generally difficult to obtain an accurate history of the mechanism of injury from a patient who has "sprained his ankle." If the clinician asks him if the foot "turned in," perhaps demonstrating this with his own foot, the patient often agrees but in an uncertain voice, agreeing out of politeness and in the hope that the doctor will be satisfied and get on with the treatment! If the ankle is

(a) (b) (c)

FIG. V. Case 3. B.J.D., age 24.

(a) Obvious widening of the interval between the talus and medial malleolus and tilting of the talus. (b) and (c) Antero-posterior and lateral radiographs after reduction and insertion of an oblique screw. It has not been found necessary or desirable to use a longer screw in these cases or in fixation of the tibio-fibular joint in the much more common fracture-dislocations of the ankle.

External rotational force sufficient to rupture the anterior inferior tibio-fibular ligament also tears the anterior capsule of the ankle joint and the tear can extend from the syndesmosis medially to the anterior fibres of the deltoid ligament. This tear is responsible for the anterior swelling and tenderness and the pain on plantar flexion of the foot, sometimes cited as a physical sign of a ruptured anterior inferior tibio-fibular ligament.

All these lesions can occur without a spiral fracture of the fibula which represents a further stage in the damage produced by the external rotation force and may occur at any level.

not carefully examined, many patients who have suffered an external rotation injury with partial or complete rupture of the anterior inferior tibio-fibular ligament may be diagnosed as having a torn lateral ligament due to an inversion strain and, as has already been mentioned, there is frequently evidence of damage to both ligaments.

The positions of the anterior inferior tibio-fibular, the anterior talo-fibular ligament and the calcaneo-fibular ligaments are shown in Fig. VIIIb. With injuries of the anterior inferior tibio-fibular ligament, there is swelling and tenderness anteriorly between the fibula and the anteromedial angle of the distal end

of the tibia. When there has been a sprain of the ligament this swelling and tenderness is slight, there is little pain on dorsiflexion and external rotation of the foot and further physical signs mentioned below as indicative of a complete rupture of the ligament are absent.

When there is a complete rupture of the ligament, the swelling is marked and if seen after several days there is frequently extensive bruising extending as high as mid-calf level (Fig. VIIIa). Due to the associated rupture of the anterior capsule of the ankle joint, there is swelling and tenderness extending across the front of the joint to the medial ligament which is also the site of tenderness due to rupture of the short fibres of this ligament.

An important physical sign of rupture of the anterior inferior tibio-fibular ligament is pain on dorsiflexion of the foot, due to separation of the malleoli by the greater width of the anterior portion of the articular surface of the talus. Pain on plantarflexion of the foot is sometimes quoted as a physical sign of this injury (Bonnin, 1957).

RADIOLOGICAL DIAGNOSIS

Watson-Jones (1955) has stated that avulsion of the medial ligament and inferior tibio-fibular ligament is difficult to diagnose clinically but is shown quite clearly in radiographs. However the radiological diagnosis may be difficult, as the diastasis is frequently momentary. The physical signs of torn ligaments indicate the true nature of the damage.

If there is radiological evidence of widening of the space between the medial malleolus and the talus (Burns, 1943) (Fig IV) or widening of the inferior tibio-fibular space (Fig. III), the diagnosis is certain. In these cases, it is important to take radiographs of the full length of the fibula to exclude a high fracture of this bone. However as Bonnin (1950) has pointed out, both these radiological signs may be absent and he and Berridge (1944) have stressed the importance of comparison of bi-malleolar views of both ankles. Bonnin (1950) states that even here there is a small margin of error and differences under one millimetre must be discounted. He has had difficulty in obtaining radiological proof of a known lesion by comparative views with strong external rotation of the foot under anaesthesia. Avulsion of a fragment of bone from the tibia (Fig. VI), from the fibula (Fig. VII), or posterior tibial fragment may indicate the precise nature of the injury.

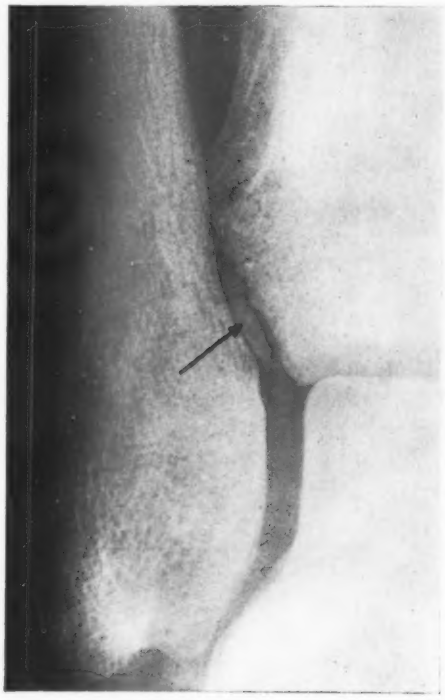


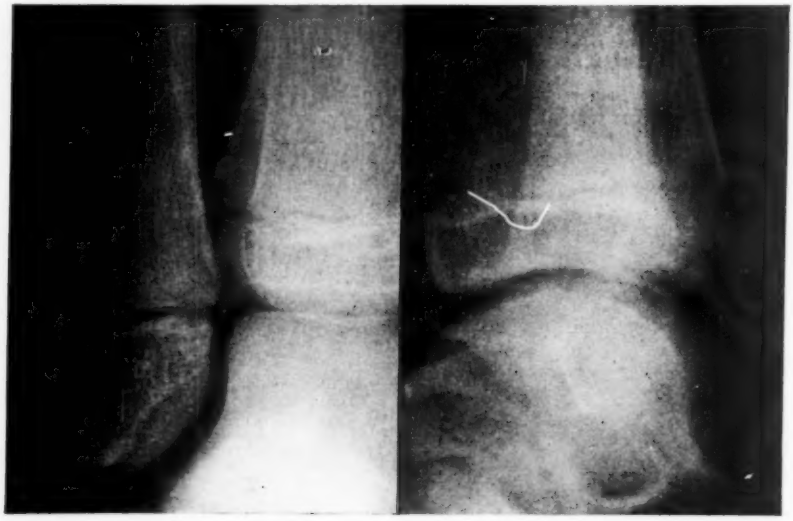
FIG. VI. Avulsion of a fragment of bone at the tibial attachment of the anterior inferior tibio-fibular ligament. This is presumably the fragment described by Tillaux (1872).

The 3 patients who underwent operation for rupture of the anterior inferior tibio-fibula ligament did so because of the severity of their local clinical condition not because of radiological appearances and whilst exhaustive studies are of interest they are not necessary for the diagnosis of these injuries.

TREATMENT

The aim of treatment of sprains of the anterior inferior tibio-fibular ligament is to minimize early stiffness and swelling by

immediate active movement and thus prevent late stiffness due to adhesion formation. Crepe or elastoplast support is applied and the patient instructed in ankle exercises and taught to walk with a normal gait from the start. Treatment is continued until there is no further pain or tendency for the ankle to swell.



(a) (b)

FIG. VII. Antero-posterior and lateral views showing avulsion of a fragment of bone from the fibular attachment of the anterior inferior tibio-fibular ligament. In this case there were signs of incomplete rupture of the ligament and the patient was treated by plaster immobilization.

Several forms of treatment have been advocated for complete ruptures of the anterior inferior tibio-fibular ligament. If the pain and swelling is not great, non-weight-bearing exercises can be instituted from the start. Initially it may be necessary for the patient to rest in bed with the foot of the bed elevated in order to disperse the swelling. A crepe or elastoplast bandage is applied and the patient continues to exercise the ankle and get about with crutches, not taking weight on the affected limb until all pain has disappeared. Usually the condition is too painful to allow this regime for pain on both flexion and extension of the ankle are prominent physical signs in this injury.

It is preferable to apply a closely fitting plaster and if there is diastasis to give a general anaesthetic and reduce it by compressing the fibula against the tibia and hold it in this position as the plaster sets. The plaster is replaced as it becomes loose and is retained for six to eight weeks depending on the severity of the initial injury and the amount of pain and tenderness present when the plaster is removed at six weeks. When the plaster is finally discarded the patient requires a further period of exercises until the range of active movement at the ankle has returned almost to normal. Some patients have been allowed to walk wearing an overboot for some of their period in plaster and this does not appear to be harmful.

Operative reduction and internal fixation has a place in the treatment of ruptures of the anterior inferior tibio-fibular ligament. Frequently patients who have been immobilized in plaster later complain of persistent pain and instability of the ankle. Furthermore some patients will not tolerate plaster and require a prolonged period of bed rest with the foot elevated before a plaster can be applied and the limb be dependent without producing pain. This situation is not common but was present in Case 1. This patient could only be made comfortable by operation which

was performed five days after injury. The disrupted syndesmosis was reduced and fixed with an oblique screw. He retained a below-knee plaster for nineteen days, was married twenty-two days after operation and was able to walk down the aisle suffering only from nervousness natural to the occasion.

of the anterior capsule and medial ligament of the ankle which have been described above. In these 2 patients a below-knee plaster was applied and worn for six weeks post-operatively. A further two weeks of ankle exercises was necessary before they could return to work.

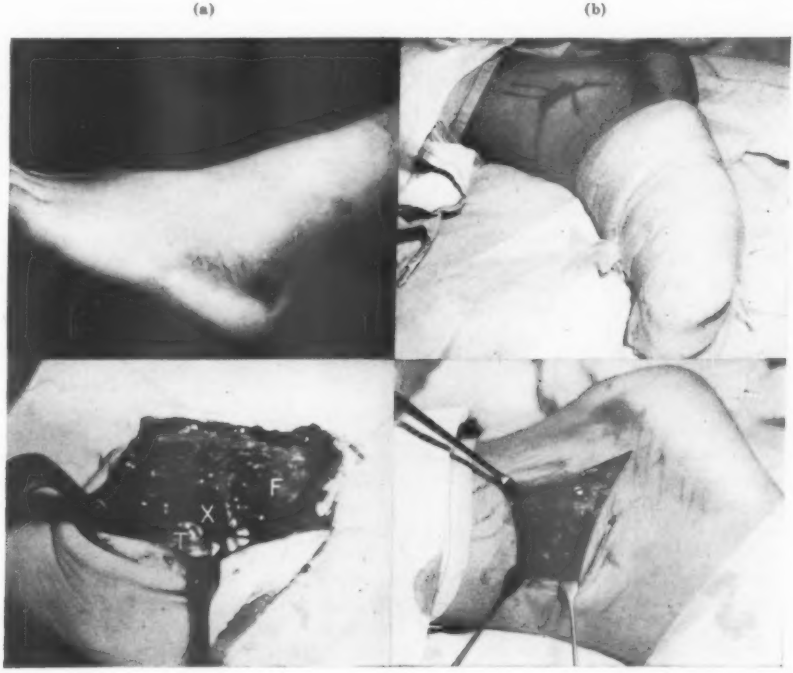


FIG. VIII

(a) The ankle of Case 1 immediately prior to operation five days following injury. There is considerable swelling over the torn anterior inferior tibio-fibular ligament and the anterior capsule of the ankle joint and the marked bruising can be seen.

(b) The ankle resting with its medial surface on a sandbag so that it falls into a position of internal rotation. The positions of the ligaments have been marked.

(c) The foot has been externally rotated and the rupture of the anterior inferior tibio-fibular ligament has allowed the inferior tibio-fibular joint to open at X. F — lateral malleolus; T — tibia.

(d) The foot has been internally rotated and the fibula pressed against the tibia and held there with a screw. The torn ligaments have been sutured.

The result in this case suggests that the indication for operation might be broadened from the above-mentioned failure of conservative treatment. Cases 2 and 3 (Figs. IV and V) both presented with obvious physical signs of rupture of the anterior inferior tibio-fibular ligament, with the associated injuries

Operation

The operation is performed with a bloodless field, the patient lying on the unaffected side with the affected ankle supported by a sandbag so that the foot tends to be internally rotated (Fig. VIIIb). A straight oblique incision, approximately 3 inches in length is

made over the lateral malleolus. The extensor retinaculum is divided at its attachment to the anterior border of the fibula and retracted medially. The anterior aspect of the inferior tibio-fibular joint is thus exposed and the nature of the injury to the ligament can be seen. The torn ends of the ligament were in 2 cases turned in between the two bones. In the third case a fragment of bone had been avulsed at the tibial attachment of the ligament. External rotation of the foot causes wide separation between the fibula and tibia anteriorly (Fig. VIIIc). In all cases there was a tear of the anterior capsule extending medially from the tibio-fibular joint to the medial ligament of the ankle joint. Holding the ankle in a position of right angled dorsiflexion an oblique screw is inserted through the inferior tibio-fibular joint, a wide drill hole in the fibula allowing the screw to press this bone firmly into its groove in the tibia (Fig. VIIId). Sutures are then inserted to approximate the torn ends of the ligament and that portion of the anterior capsule tear which can be reached. In the case in which the anterior tibial tubercle was avulsed this was sewn in place by periosteal sutures. Suturing the ligament can be difficult and is probably not essential once the torn ends are placed in contact as they are held together by the oblique screw. The extensor retinaculum is then reconstituted by several interrupted sutures. After skin closure a well-padded plaster is applied. As has already been mentioned the plaster was worn for three weeks in one instance and for six weeks in the other two patients. The shorter period appears to be satisfactory and it allows earlier return of movement and resumption of work.

The screw is removed through a small incision, under local anaesthesia, approximately six weeks post-operatively. It is removed to allow return of the normal movement of the inferior tibio-fibular point, which, although small in range, is important in endowing the mortice with resilience rather than rigidity.

Results of operative treatment

One patient on whom the above described operation was performed thirty-one months ago was recently reviewed. He had no symptoms and plays rugby and squash. The scar was inconspicuous, there was no swelling and the range of ankle movement equalled that in the unaffected ankle. The other two patients underwent operation too recently for the long term results to be assessed. As has already been mentioned the three cases on whom operation was performed have been included in this article chiefly because operation revealed the traumatic anatomy of rupture of the anterior inferior tibio-fibular ligament and the associated lesions.

DISCUSSION

That operative treatment may prove to be the treatment of choice in ruptures of the anterior inferior tibio-fibular ligament is suggested by several facts. It has been mentioned above that the only way in which some patients with rupture of the ligament may be made comfortable is by operation. The torn ends of the ligament were found in 2 cases to be between the separated bone ends which suggests that operation may be the only way in which the normal anatomy of the joint can be restored. The mass of hyalinized connective tissue between the fibula and talus, described by Wolin *et alii* (1950) as occurring in patients suffering from persistent pain and swelling over the fibular aspect of the ankle following a sprain, may be formed from a torn end of the anterior inferior tibiofibular ligament lying between the fibula and talus. Furthermore, in this small number of cases, the convalescence has been uncomplicated and a full range of painless ankle movement has rapidly returned. The precise indications for operative treatment are not yet clear and only a long term of study of patients treated by conservative and operative methods will clarify the situation.

SUMMARY

1. The anterior inferior tibio-fibular ligament may suffer a sprain, a complete rupture or may avulse a flake of bone from either of its attachments.
2. These injuries may be due to either internal rotation of the mortice on the fixed talus or to inversion of the foot while under load.
3. In cases of rupture of the anterior inferior tibio-fibular ligament there is in addition damage to the anterior capsule and medial ligament of the ankle joint.

4. The clinical features of these injuries are described. Simple physical signs provide much information about the exact nature of the lesions present; the radiographic diagnosis may be difficult.
5. Several forms of treatment for rupture of the anterior inferior tibio-fibular ligament are described.
6. The procedure and findings at operation, performed on 3 patients with rupture of the ligament, are described. The good results in these cases suggest that operation has a place in the treatment of this injury. The indications for operative treatment are not yet clear but it provides the only method by which a complete restoration of the normal anatomy can be assured.

ACKNOWLEDGEMENT

I am indebted to Mr. William Gissane who suggested this article. Many of the observations included are his and I appreciate his helpful advice and permission to include cases under his care.

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CARCINOMA OF THE URETHRA*

By L. J. Opit

Department of Surgery, University of Adelaide

CARCINOMA of the male urethra, although rare, is now a well recognized clinical entity. Hotchkiss and Amelar (1954) quote 230 described cases and further cases have been added since that time. The prognosis is bad and remains so in spite of considerable improvements in surgical technique. Examination of recent reports suggests that this is at least in part due to the lateness of diagnosis. That diagnosis should be so late is surprising for, by the nature and site of the tumour, symptoms are produced reasonably early in the natural history of the disease. Usually this condition is labelled as a benign stricture and by the time the malignant nature of the obstruction is manifest the disease has already progressed so widely locally that only palliative urinary diversion or excessively mutilating surgery can be offered to the patient.

Two further case reports are presented illustrating the problems of diagnosis and therapy in this disease.

Case 1

E.S. aet. 74 yrs., was admitted to the Royal Adelaide Hospital on 7 Jan. 1958 with a history of burning and scalding of micturition for about two months. He had also noticed that there was pain and swelling in the region of the scrotum for the month prior to admission. During this time his own practitioner had treated him with sulpha tablets. He said he had had a 'growth' removed from the bladder in 1955.

On examination the significant abnormalities were abdominal tenderness on suprapubic examination, firm non-tender inguinal nodes palpable in both groins and in the perineum a hard mass involving the bulb. This mass was about 6 cm. in diameter and on rectal examination it was thought not to extend above the region of the perineal membrane.

A provisional diagnosis of either chronic periurethral abscess or urethral carcinoma was made. Following local incision biopsy confirmed a squamous celled carcinoma with attempts at cornification in some areas and a transitional appearance in others (Fig. I). A suprapubic cystostomy was done. The bladder was normal at the cystostomy and no sign of tumour in the bladder or prostatic urethra was evident.

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On 3 Feb. 1958 total amputation of the penis and urethra up to the perineal membrane was performed. At the time it was thought that the tumour occupied the whole bulb up to but not beyond the perineal membrane and extended distally about 6 cm. The fibrous tissue of the corpora cavernosa was not infiltrated macroscopically.

He recovered well from this operation but by April 1958 local recurrence was evident in the perineum. Radiotherapy was considered but not recommended. His condition deteriorated rapidly and he died on 12 April.

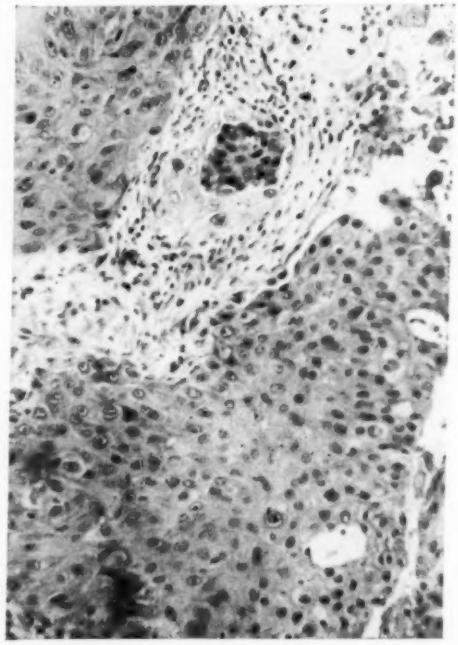


FIG. I. Section of the tumour of Case 1. This shows anaplastic squamous cell carcinoma.

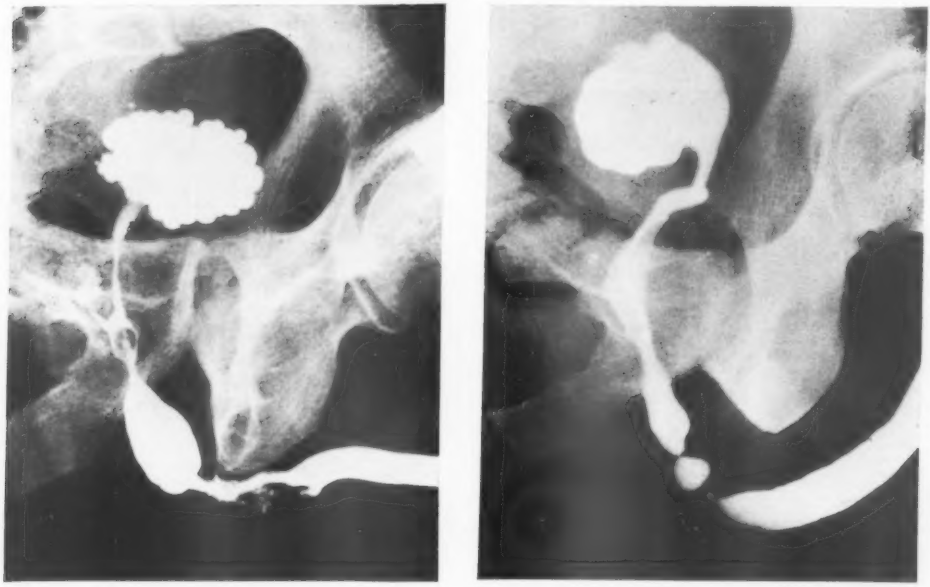
Case 2

C.R.N. aet. 56 yrs. presented at the Queen Elizabeth Hospital in April 1959 with a history of nocturnal frequency for some years. A few days before admission he began to have increasing frequency and difficulty in voiding. He had also noticed that his stream was poor. There had been no history of previous urethritis.

Examination at this time showed only slightly firm tender prostatic enlargement. An intravenous pyelogram showed normal function with normal pyelograms. The outline of the bladder was slightly crenated and there were innumerable calculi present in the right prostatic lobe. A large amount of residual urine was evident after micturition. He was admitted for cystoscopy. At this procedure a stricture was discovered in the bulb. After dilatation a cystoscope was passed. The bladder was slightly trabeculated but no other abnormality was commented upon. A urethrogram (Fig. II) showed a long irregular stricture just anterior to the bulb. Unfortunately the significance of this urethrographic appearance was not recognized at the time and no further effort was made to elucidate the 'stricture' during this admission. He was treated by intermittent dilatation until August 1959 when a hard perineal mass was palpated. This mass was ovoid and measured 4 cm. by 3 cm. The suspicion of urethral carcinoma was now raised and panendoscopy showed a shaggy ulcerated urethra corresponding to the mass with normal urethra proximal and distal to it. A satisfactory biopsy through the panendoscope was not obtained, and biopsy from the perineum was performed. This showed an anaplastic transitional-like carcinoma with some areas of primitive epithelial pearl formation (Fig. III).

A preliminary suprapubic cystostomy was performed during September 1959 and treatment by radiotherapy of 60,000 r. over forty-two days was applied to the perineum with the orthotron. There was virtually no response and the mass soon began to enlarge again.

It was felt that surgical extirpation had little chance of success. Intermittent perineal leakage of urine caused the patient considerable discomfort and because of this a bilateral uretero-sigmoidostomy was performed by the method of Leadbetter on the 22 Dec. 1959. The patient made an uneventful recovery from this and was discharged on the 24 Jan. 1960.



(a) (b)

FIG. II. (a) Urethrogram (ascending) of Case 2. Note the long isolated stricture with space-occupying lesion unlike that of inflammatory strictures shown in (b) for comparison.

DISCUSSION

This condition represents the problem of a rare disease masquerading as a common one. Two main issues seem unresolved. First, what measures can be taken to ensure earlier recognition and secondly what is the best therapy which can be offered to the patient, particularly in the more advanced cases?

The two main sites of origin of this neoplasm are at the external meatus or in the bulb. The former site comprises about one quarter of the cases (Riches and Cullen, 1951; Flocks, 1956). Lesions here are easily recognized and carry a good prognosis. Nansen (1951), reviewing the literature at that time quotes Kreutzmann and Colloff (1939) as obtaining 54 per cent. cure from carcinomata in this site. The present paper, however, is concerned with the more common and

unsatisfactory lesions in the bulb. It is felt that a review of some of the known clinical and pathological facts might help.

Goldstein and Abehouse (1937) quote the age incidence in reported cases as ranging from 18 years to 91 years. The majority of cases, however, occur in the 4th and 5th decade.

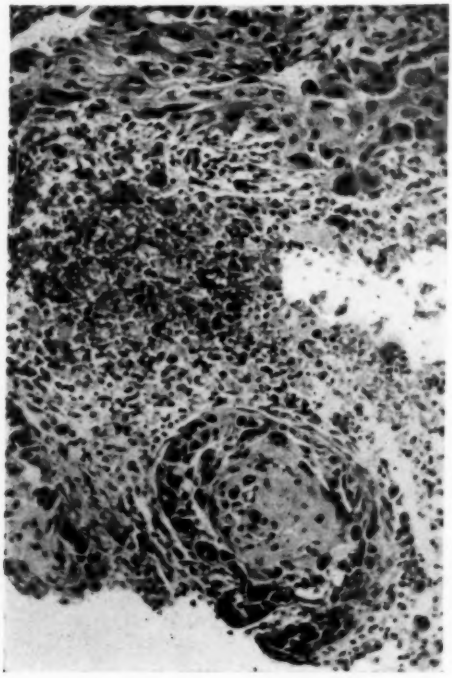


FIG. III. Section of tumour in Case 2. This shows epithelial pearl formation.

One fact of aetiological significance emerges from every series and that is an association between gonococcal urethritis with stricture and carcinoma of the bulb. Riches and Cullen (1951) reported this history in 4 out of 9 cases, Thomson-Walker (1948) in 50 per cent., Lowsley and Kirwin (1944) in 66 per cent. and Kreutzman and Colloff (1939) in 76 per cent. How these lesions are in fact related is speculative but the squamous neoplasia of chronic urethral inflammation is well known. Another association exists between carcinoma of the bladder and carcinoma of the urethra. Three cases of a total of 15 of urethral carcinoma reported by Riches had associated bladder tumours. In 2 of these there was no obvious continuity.

Histologically, these tumours are usually squamous-celled and this is in accord with an origin associated with chronic inflammation. About one-third of the cases are transitional cell in type and these particularly are associated with vesical lesions. Lymph nodes appear to be involved in about 50 per cent. of patients. The tumour itself is usually fast-growing and aggressive.

Clinical presentation

Carcinoma of the deep urethra presents as a urethral stricture or one of its complications such as periurethral abscess. There is nothing characteristic of carcinoma in this site except its rate of progress. Especially when a long history of previous dysuria or stricture is given, there is little to arouse suspicion until the lesion is so advanced that any hope of successful treatment is only possible with radical and mutilating surgery.

It is felt that if adequate diagnostic procedures were adopted in all cases of stricture, particularly when the stricture develops in late middle age, a material improvement in prognosis might be achieved. The ascending urethrogram would seem to be a particularly useful routine for urethral stricture.

Only too often the diagnosis of stricture rests on blind instrumentation of the urethra and this, coupled with a lack of awareness of a stricture being malignant, leads to considerable delay. In Case 2 reported here it was this very factor which prevented further investigation of what was in retrospect a most suspicious urethrogram.

Treatment

Opinion differs widely amongst the various authors. Riches and Cullen (1951) state that the majority of cases come too late for other than radical surgery or irradiation. Certainly the majority of patients respond little to treatment with conventional X-ray therapy. Two cases reported by Hotchkiss and Amelar (1954), however, apparently responded well to node irradiation. Neither of these tumours was the common squamous-celled carcinoma. The place of super-voltage therapy is not yet defined but the poor response of Case 2 does nothing to justify optimism. Two cases of posterior urethral carcinoma in males

reported by Lower and Hansfeld (1947) were very successfully treated by local excision and anastomosis. This is obviously the most desirable, but rarely possible, form of treatment with the present state of diagnosis.

Radical excision of the penis will occasionally be possible as a curative measure, but as a rule it is difficult pre-operatively to assess satisfactorily the criteria of operability in relation to cephalward spread. There have been a small number of successful cases treated in this fashion.

Marshall (1957) reported an even more radical approach with considerable improvement in prognosis. He recommended total excision of the penis, prostate and bladder, combined with iliac gland dissection. Bilateral inguinal gland dissection was also performed if nodes were palpable.

Unfortunately, all that can be offered to the majority of patients is palliative urinary diversion.

SUMMARY

Two cases of carcinoma of the deep urethra in males are reported.

The poor prognosis of this lesion is again confirmed.

The clinical course and features of carcinoma of the bulb of the urethra are reviewed.

It is suggested that improvement in prognosis will come from earlier diagnosis.

This will only be possible by full urological investigation of cases of urethral stricture and an awareness of the disease.

ACKNOWLEDGEMENTS

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ANGIOGRAPHY IN HEAD INJURIES*

By G. VANDERFIELD

Sydney

IN this paper it is proposed to indicate and illustrate the value of cerebral angiography in recognizing the presence of cerebral complications in head injuries.

In recent years in dealing with head injuries much attention has been given, with advantage, to such measures as tracheotomy to avoid chest complications and the correction of electrolytes to prevent metabolic disorders, but there has been little consideration of means to improve the detection of intracranial haematomata and other remediable conditions which have not presented clear-cut evidence of their presence.

Many head injuries in this country have to be dealt with by surgeons not accustomed to the use of the newer intracranial investigations and in hospitals not equipped to carry them out. These tests are electroencephalography and cerebral angiography. Where they are available the relative value of each is not generally appreciated. When the limitations of electroencephalography were discussed (Money and Vanderfield, 1953) it was shown that the procedure had been found unreliable and of little practical help in the earlier stages of head injuries.

In this period, that is within the first three weeks after head injuries, cerebral angiography has proved a much more reliable and helpful procedure. It has often guided the successful management of cases presenting clinical difficulty and seems to warrant a fuller discussion of its place in the care of head injuries.

FREQUENCY OF USE

Since 1952 the procedure has been carried out in 90 cases, which represents about 11.6 per cent. of the 778 head injuries seen in this time.

*Received for publication 12th November, 1959.

No more precise indication of the frequency of its use is made as the cases dealt with here are highly selected being either seen in consultation because of possible neurosurgical implications or later because the persistence of symptoms might have been of medico-legal significance.

The loading of the series with severe and difficult cases is indicated by the fact that of the 50 cases of head injury in whom angiography was performed 32 (64 per cent.) needed operation.

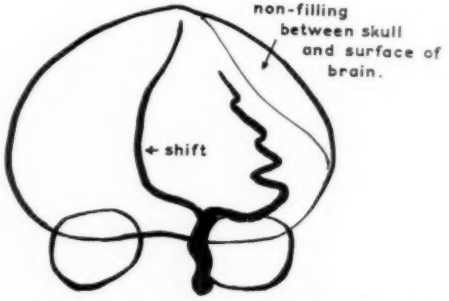

FIG. I. Anteroposterior arteriogram showing subdural haematoma.

TIMING OF ANGIOGRAPHY

The procedure has been performed in this series as soon as four hours after the injury. A boy was brought to the hospital within two hours of having been struck at the inner angle to the right eye with a sharp metal spike. It was said to have penetrated $\frac{1}{2}$" but the boy had immediately become stupefied and weak down the left side and under observation this was becoming complete. The right pupil was dilated and plain X-rays showed no fracture or indriven metal. Right carotid angiography by demonstrating the absence of shift in normally filled blood vessels excluded any immediate surgical implications and was therefore clinically of great help in deciding management.

The earliest a haematoma was found and successfully removed occurred when angiography was carried out within sixteen hours of injury. A 34-year-old man was found unconscious after a fall; he had a left hemiplegia, his eyes deviated to the left but the pupils were equal. It was felt he may have had a sub-arachnoid haemorrhage from a coincident aneurysmal rupture. Right cerebral angiography demonstrated a space occupying lesion on the left side and left carotid angiography confirmed the presence of a surface clot on the left and excluded any associated aneurysm. (See diagram in Fig. I.)*

TABLE 1

TIME BETWEEN INJURY AND ANGIOGRAPHY IN 50 CASES

Time	*Number*
Within 3 days	7
Between 3 days and 3 weeks	30
Later	13

However, many cases have not been seen before the 3rd day and rather more than half not till after the third week. Considering this and a detailed analysis of the cases summarized in Table 1 it seems that angiography is most often called for any time within the first three weeks, and thereafter its use drops that of a routine investigation of symptoms and signs such as headaches, seizures and visual disturbances.

In about 10 per cent. of cases angiography was repeated 2 or 3 times to assess the significance of fresh developments. Where this occurred the time given refers to the first procedure only.

DIAGNOSTIC VALUE

In just over half of the cases angiography established a positive diagnosis. In the "negative" cases in the earlier stages the fact that the need for surgery was excluded was usually of important assistance in the direction of medical measures. Later on, negative findings were helpful in assessment of persistent signs and symptoms.

Table 2 classifies the 47 positive diagnoses made.

TABLE 2

POSITIVE DIAGNOSIS

	Number
Intracranial haematomata	33
Extradural	4
Acute subdural and intracerebral	15
Chronic subdural (more than 14 days)	14
Localized brain swelling	2
Brain abscess	2
Carotid thrombosis	2
Post-traumatic aneurysm	2
Pre-existent lesions	6
Aneurysm and angioma	5
Tumour	1
	47

Some features in the above pathological groups deserve special mention.

1. *Intracranial haematomata*

Though these develop in a small proportion of head injuries their recognition is important because they are often acute operative problems and also carry a high mortality rate if not treated.

Atypical extradural haematoma

Whilst in classical cases burr hole exploration is often called for as a matter of urgency and there is no justification for delaying to investigate, there are cases where a haematoma will be missed by a burr hole in the usual site; and in these immediate angiography might be rewarded; Fig. II shows the appearances in a haematoma at the frontal pole. Other cases are atypical in being slow to present; in this series 2 cases diagnosed by angiography did not present till the eleventh

*Line drawings are used to illustrate carotid angiograms. The internal carotid artery and its main branches are shown on conventional skull outlines. Where there is displacement the direction and extent is indicated by an arrow.

and twenty-first days after injury and then because of severe headaches and giddiness which had been dismissed as post-concussional syndrome.

Acute subdural and intracerebral haematoma

Diagnosis of these lesions after injury can present similar problems and they sometimes occur in association so they are considered together. Within the first few days haematomas are often suspected because of deterioration or neurological signs but sometimes difficulties arise in deciding whether surgical intervention will help and if so where; on other occasions the absence of any history adds to clinical doubts. It is in some of the problems that angiography can be of considerable assistance as the following case illustrates.

With a 13-year-old girl there was a dubious history of slight head injury sixty hours earlier. At first she was said to be all right but about thirty-six hours afterwards her conscious level had deteriorated and this led to her admission with a diagnosis of subarachnoid haemorrhage; she was found to have a *left* hemiparesis and a *left* 3rd nerve lesion. X-rays and an E.E.G. did not disclose any definite abnormality. Angiography as illustrated in Fig. III demonstrated shift due to a left temporal lesion which proved to be a subdural haematoma and swollen brain which had caused false localizing signs.

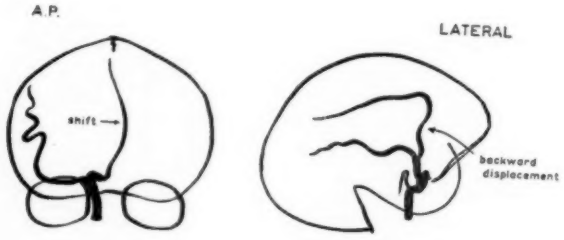

FIG. II. Anteroposterior and lateral arteriograms of displacement due to haematoma at the frontal pole.

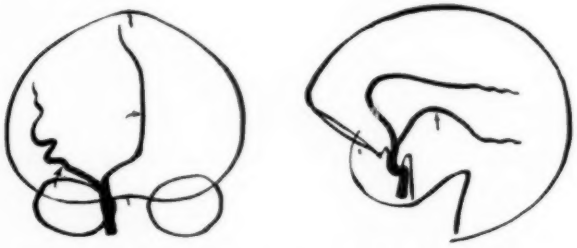

FIG. III. Anteroposterior and lateral drawings of displacements caused by haematoma over contused left temporal lobe.

Sometimes too there is the possibility of the accident being due to pre-existent lesions and this can make it difficult to decide whether the neurological state is a result of the injury or not. A 72-year-old male had been operated for cancer of the rectum twelve months earlier. He had fallen and bruised the left temple. After initially recovering he became disorientated and developed a left hemiparesis. A spontaneous cerbro-vascular accident or intracranial metastases were considered in the diagnosis but a left temporal fracture seen in the plain X-rays and a carotid shift seen on angiography led to the diagnosis of intracerebral and subdural haematoma on the right, and successful treatment followed.

Chronic subdural haematoma

Later on the persistence or development of symptoms may arouse suspicion of a subdural collection and angiography can be helpful in diagnosing the presence and site of such lesions.

2. *Abscess*

Despite the frequent use of antibiotics intracranial infections may occur following compound or basal fractures. Angiography assisted in 4 cases where abscess was suspected; in 2 by demonstrating a space-occupying lesion, and in 2 by excluding one.

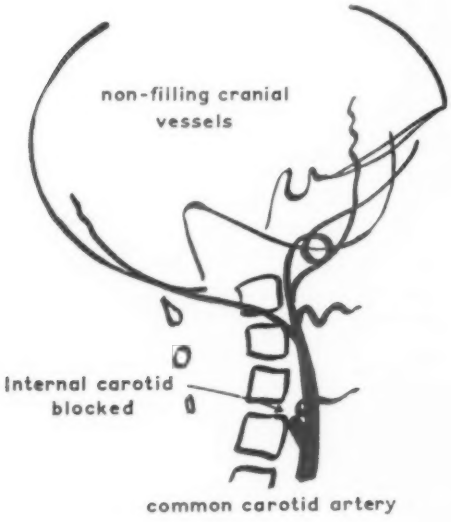

FIG. IV. Thrombosis of internal carotid artery close to its origin.

3. *Carotid thrombosis*

In each of these cases there was some injury to the neck as well as to the head but the neurological deficit of hemiplegia was out of proportion to the other findings.

A patient though still conscious following a head injury had become hemiplegic; angiography demonstrated a block in the internal carotid artery 1 cm. from the bifurcation as shown in Fig. IV.

4. *Post-traumatic aneurysm*

In one case a carotico-cavernous fistula was confirmed, and in another an internal carotid aneurysm which developed some weeks after the injury was demonstrated. This case was of special interest and in this instance angiography was used on 3 separate occasions (Fig. V). Firstly on the night of the accident left carotid angiography excluded any sizable haematoma. His recovery was interrupted by epistaxis and subarachoid bleeding, where a repeat of the left carotid angiography now showed a large internal carotid aneurysm. Carotid ligations appeared to control the bleeding but later deterioration called for right cerebral angiography which indicated that a left frontal haematoma had formed.

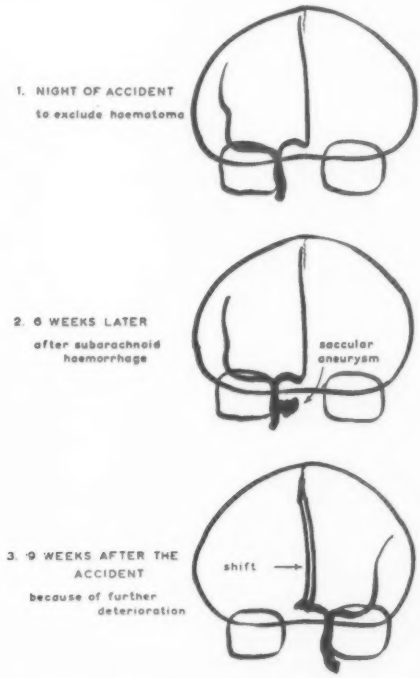

FIG. V. The series of anteroposterior angiograms in the same case at intervals each revealing different information. The third angiogram was taken on the other side as carotid ligation had been performed in treating the aneurysm revealed by the second procedure.

5. *Pre-existent lesions*

In 5 cases an unsuspected aneurysm or angioma was discovered. In 3 of these there was some discrepancy between the severity of the findings and the relatively minor head injury associated; an example is the angioma illustrated in Fig. VI. In the other 2 the

angiograms were done at a later stage, in one because of epilepsy, and the other because of a subarachnoid haemorrhage. In the sixth case the symptoms of cerebral tumour were brought on by an injury; immediate admission to hospital was necessary and over the next twelve months gradual improvement occurred, but then his condition deteriorated and he had angiography which demonstrated a vascular displacement due to tumour. As well there were 2 cases who had previously had a primary carcinoma of the bowel removed and the question of cerebral metastasis had to be considered.

FIG. VI. Lateral angiogram revealing pre-existent angioma.

7. *Localizing value*

The commonest surgical complications of head injury which need to be identified or excluded are intracranial haematomas. These are readily diagnosable by angiography unless they are shallow or as is uncommon, are posteriorly placed.

Detailed consideration of the 13 intradural haematomas correctly diagnosed by angiography since 1956 demonstrates its superiority to other methods to which comparison is made in Table 3.

During the same period in 1 case angiography suggested a posterior midline extradural haematoma but was not found by direct exploration.

In the above cases where a fracture was present, apart from bilateral or midline lesions, it was on the side of the haematoma twice and on the opposite side 3 times.

INDICATIONS

Broadly speaking carotid angiography is indicated whenever the clinical features leave doubt as to the intracranial pathology following head injury.

TABLE 3

OTHER FINDINGS IN 13 HAEMATOMATA CORRECTLY LATERALIZED BY ANGIOGRAPHY

Clinical Feature	*Lateralization indicated*		
	Correct	*None*	*Wrong*
E.E.G. (not done in 3)	5	4	1
Pupils	2	9	2
Hemiparesis and reflex changes	5	6	2

In the early stages angiography should not delay surgery when it is already sufficiently indicated nor should it be allowed to replace proper clinical judgement in those cases suffering from no more than the expected effects of their injuries. However there are still a number of other cases where life may be threatened, and in which no history is available or the signs are conflicting. In many of these the problem can often be quickly decided by angiography enabling a prompt decision as to whether cranial surgery is indicated, thus avoiding many hours of "wait or see" anxiety or unnecessary misplaced burr hole explorations.

Later on, the persistence of symptoms or unexpected developments can often be clarified by these studies.

ADVANTAGES

1. Ready availability on a fully staffed neurosurgical service.
2. Relative simplicity: in trained hands it is quick and easily performed.
3. Minimal disturbances to patient's condition as it can be done under local anaesthetic or with a little pentothal or largactil intravenously.

4. Diagnostic usefulness and accuracy. In head injuries it has been more informative and reliable than alternative investigations.

CONCLUSIONS

This procedure is a valuable and versatile investigation and its use is a major development in the management of head injuries. It has proved its superiority to other methods in cases presenting difficulty clinically. The foregoing demonstrates the potential value of cerebral angiography but it cannot be more fully realized in this country until the care of head injuries is better integrated with neurosurgical services.

ACKNOWLEDGEMENT

I am grateful to Dr. R. A. Money for much practical and valuable advice on this subject.

REFERENCE

MONEY, R. A. and VANDERFIELD, G. K. (1953), "The Value of Electroencephalography in the Management of Head Injuries," Annual Meeting of the Neurosurgical Society of Australasia.

THE PHYSIOLOGY OF VISCERAL SENSATION AND REFERRED PAIN*

By J. G. McLeod

Royal Prince Alfred Hospital, Sydney

ALTHOUGH a considerable amount of information has been collected in recent years on the subject of cutaneous sensation, the physiology of visceral sensation has not been so closely studied and is not so well understood. The object of the present article is to review in the light of recent research our present state of knowledge of the physiology of visceral sensation and referred pain.

Visceral Sensations

(1) *True visceral pain* arises from the viscera themselves and it may be referred or unreferred. It is not to be confused with the painful sensation which may be experienced from stimulation of the body wall and its lining of serous membrane and which may be also referred or unreferred. Visceral pain is mainly transmitted in the sympathetic nerves, except for that arising from the pelvic organs which is conducted in the sacral nerves (White, 1943). The evidence concerning the role of the vagus (parasympathetic) in the transmission of pain is conflicting. Cannon (1933) could not elicit responses associated with painful sensations on stimulation of the cat's vagus, although White (1943) claims that the vagi carry uncomfortable sensations from the tracheo-bronchial tree, oesophagus and heart but have no part in the transmission of gastro-intestinal pain.

Hurst's (1911) work largely dispelled Lennander's (1903) mistaken belief that the viscera were totally insensitive by demonstrating that distension and contraction were the types of stimulus required to arouse painful sensations. In addition to these, pain may also be aroused by direct irritation of free nerve endings, as in the floor of an ulcer, and of course inflammation will render an organ more sensitive to painful stimuli.

Visceral pain is transmitted mainly in the sympathetic thoraco-lumbar outflow which supplies sensory fibres to the abdominal and pelvic viscera by way of the splanchnic nerves. Leriche (1937) showed that electrical stimulation of the splanchnic nerve gave rise to pain and it is well known that pain sense from the abdominal viscera can be abolished by splanchnicectomy (Bentley and Smithwick, 1940; Ray and Neill, 1947).

It has been demonstrated that in cutaneous nerves there is a rough correlation between the size of the sensory nerve fibre and the type of sensation which it is responsible for transmitting (Gasser, 1943; Gaze and Gordon, 1954). Thus the largest fibres — the $A\alpha\beta$ fibres (from 12-20 μ in diameter) transmit sensations of touch while the smaller myelinated fibres, the $A\gamma\delta$ fibres (about 4 μ in diameter) and the unmyelinated C fibres carry the sensations of pain and temperature. The afferent fibres in the splanchnic nerves are similar to those in cutaneous nerves, except that there are fewer of the large fibres. Most of the fibres are in the 4-8 μ range and are thus of a similar size to the pain transmitting fibres in cutaneous nerves. It has been shown that painful reactions occur only when this group of smaller myelinated or the unmyelinated C fibres are stimulated (Gernandt and Zotterman, 1946).

These sensory fibres in the sympathetic system follow much the same course in the central nervous system as do somatic afferent fibres. They have cell bodies in the posterior nerve roots and the larger fibres travel upwards in the posterior columns of the spinal cord and relay in the postero-lateral ventral nucleus of the thalamus in close association with the sensory fibres from the body surface which are mainly those derived from the skin of the trunk. Some of these relay to the cerebral cortex. The smaller myelinated afferent fibres from the viscera in the size-range which we associate with the transmission of the sensation of pain course upwards

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in the antero-lateral columns with the spino-thalamic tracts and are also represented in the postero-lateral ventral nucleus of the thalamus with the skin afferents (McLeod, 1958) (Fig. I). It has not been conclusively shown that these fibres project to the cerebral cortex and there is evidence that pain may be appreciated at the thalamic level (Walker, 1938).

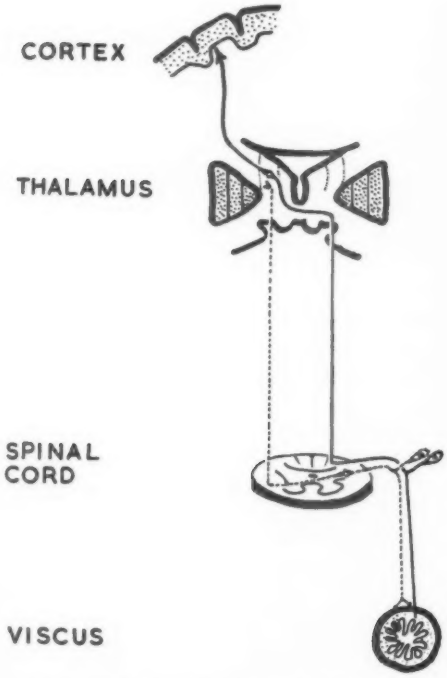

FIG. I. The pathways of the sympathetic afferent fibres in the central nervous system. The large (A$\alpha\beta$) fibres run cranially in the posterior columns and the smaller (A$\gamma\delta$) fibres in the antero-lateral columns to the postero-lateral ventral nucleus of the thalamus. The large fibres project to the cerebral cortex.

It therefore seems clear that the gastro-intestinal tract receives a sensory supply through the splanchnic system which has much the same pathway in the central nervous system as the sensory supply from the body surface, but it contains fewer of the large fibres which are known to respond to touch. The innervation of the gut is much sparser than that of the skin, resulting in a higher threshold to stimulation and a poorer localization of sensation.

(2) *Organic sensations* are those vague feelings which are thought to have their origin in the viscera, such as hunger, satiety, nausea and sense of fullness. They appear to be transmitted in the parasympathetic division or cranio-sacral outflow which supplies sensory fibres to the thoracic, abdominal and pelvic viscera by way of the vagus and the sacral nerves, S2, 3, 4 (White, 1943).

The vagus supplies the thoracic and abdominal viscera and it has been shown (White, 1943) that sensations of hunger, satiety and sense of fullness are intact after such neurosurgical procedures as antero-lateral cordotomy, posterior rhizotomy and transection of the spinal cord which interrupt the sympathetic afferent pathways. The idea that the vagal afferent fibres conduct organic sensations has received additional support from the work of Iggo (1955, 1957) who has shown that they are attached to stretch receptors in the gut wall. These stretch receptors are in series with smooth muscle cells and fire off impulses in response to both contraction and stretch. The rate of discharge was found to be proportional to the rate of distension.

The sensory fibres of the pelvic vagus which supplies the pelvic organs enter the spinal cord through the second, third and fourth sacral segments and travel cranially in the midline portion of the posterior columns ending in close relationship to the cervical vagus, in the tractus solitarius. These fibres are also attached to stretch receptors and it has been shown that passive stretching of the bladder stimulates activity in these fibres (Iggo, 1955; Yamamoto, Sugihara and Kuru, 1956).

The ultimate destination of the pathways for organic sensations in the higher centres of the brain differs from that of the pain sensations. There is no evidence that vagal afferents project to the posterior ventral nucleus of the thalamus and to the cortical sensory areas as do the somatic afferents and the visceral sympathetic afferents and so the appreciation of the sensations which they transmit must reach consciousness in a different manner. They appear to project to thalamic nuclei close to the midline (ventro-median, submedian and interventral nuclei),

(Dell and Olsen, 1951). The organic sensations arising from viscera are poorly localized and are not referred to distant sites in the same way as are the painful sensations.

Doran and Ratcliffe's (1954) finding that pain can be referred to completely denervated skin areas, although this denervation raises the pain threshold.

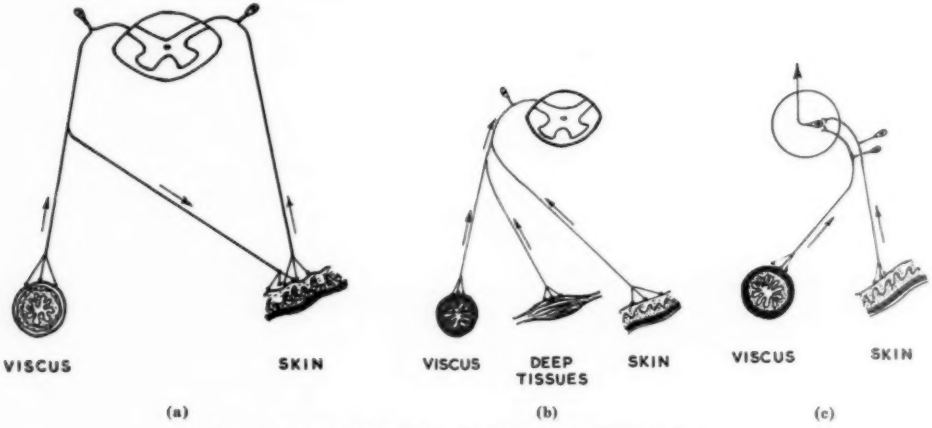

FIG. II. The neurological basis of theories of referred pain.

(a) Peripheral theory. Impulses originating in the diseased viscus run antidromically to the skin, releasing there chemical substances which stimulate cutaneous sensory fibres.

(b) Theory of branching fibres. Visceral afferent fibres branch, sending axons to the skin and deep somatic structures. This could account for central misinterpretation of the source of stimulus and for cutaneous and deep hyperalgesia.

(c) Central convergence theory. Afferent pathways from the skin and from the viscera converge on to common neurones in the central nervous system.

Referred pain

It has been known for many years that visceral disease gives rise to pain localized to the body surface, as well as to cutaneous hyperalgesia, muscular rigidity, and autonomic manifestations such as flushing and sweating. Few of the theories put forward to explain this reference of pain were based on sound experimental evidence. Theories explaining referred pain have developed along two main lines:—

(1) The peripheral theory, which suggested that impulses originating in the diseased viscus ran antidromically to the skin, setting up there a painful stimulus to cutaneous sensory fibres by releasing chemical substances (Penfield, 1925) (Fig. IIa). More recently, Sinclair, Weddell and Feindel (1948) have developed a theory of branching fibres to explain referred pain but it is not substantiated by present anatomical and physiological evidence (Fig. IIb). The peripheral theory does not adequately explain the reference of pain to phantom limbs or to completely anaesthetized areas and is difficult to reconcile with

(2) The central convergence theory, according to which referred pain is caused by the convergence of the somatic and visceral afferent pathways in the central nervous system (Fig. IIc). This theory was advanced by Sturge (1883) to account for the pain in the chest, arms and neck in angina pectoris and was developed and enlarged with some modifications by Head (1893) and Mackenzie (1909). Convergence in the central nervous system is apparently quite common and has been observed in many situations. Mountcastle, Covian and Harrison (1952) demonstrated it in the cortex between deep and superficial somatic pathways, and it has been demonstrated between cutaneous fibres arising from different skin areas (Amassian, 1952; Cohen and Grundfest, 1954). Convergence between cutaneous and visceral afferent pathways was sought in the thalamus (McLeod, 1958) by locating single nerve cells which fired off in response to stimulating the visceral afferent pathways (the splanchnic nerve was used for this purpose) and then determining whether these same cells could also

be made to respond in the same way to stimulating an appropriate skin area. A good many of these cells did, in fact, respond to stimuli from both sources and many of these were connected with the smaller $A\gamma\delta$ fibres in the splanchnic nerves which are known to mediate pain and painful reactions (Fig. III).

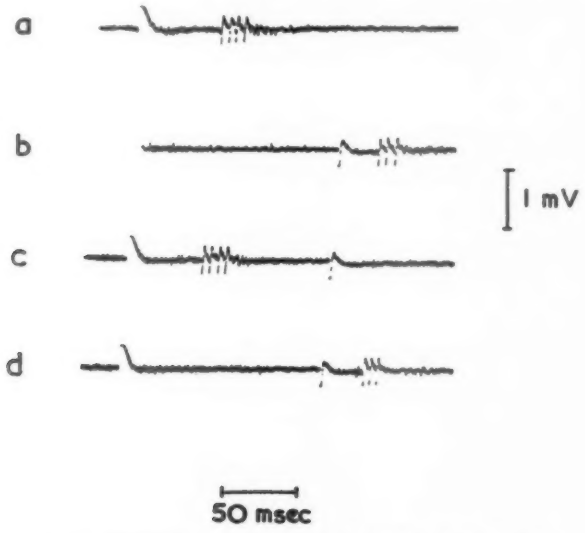

FIG. III. Activation and occlusion of a thalamic unit by stimulating splanchnic and cutaneous afferent pathways. Cat: sodium pentobarbitone.

(a) Response of thalamic unit to single-shock stimulation of the $A\alpha\beta$ fibres in the splanchnic nerve.

(b) Response of the same unit to stimulation of the skin of the forefoot.

(c) The response to stimulation of the skin blocked by a previous response to stimulation of the splanchnic nerve.

(d) Activation of the thalamic unit by the skin stimulus occurs when the response to previous stimulation of the splanchnic nerve has failed.

These experiments provided direct proof that although some visceral afferent fibres to the thalamus are direct, convergence takes place at or below thalamic level between many of them and the cutaneous pathways. This synaptic convergence mechanism offers a neurological basis for reference of pain to parts of the body surface. The actual conscious misinterpretation of the source of pain results from this convergence and can probably be explained along the following lines. It is well known that visceral sensations are poorly localized and the poverty of innervation of the gut accounts for this to some extent. In addition, however, the ability to localize depends largely on experience and learning, and since the viscera have no position sense and can neither be seen nor touched, the sense of localization can never be properly developed. For this reason, impulses from the viscera, since they travel along a pathway common to both visceral and cutaneous areas are more readily interpreted in consciousness as coming from cutaneous areas which are more familiar and more readily localized. The fact that there seems to be an element of true visceral pain which is unreferred and whose real source is recognized probably depends on the amount of activity in the direct pathways on which there is no convergence.

Cutaneous hyperalgesia in visceral disease is most likely due to the visceral impulses lowering the post-synaptic threshold at the site of convergence so that cutaneous impulses more easily excite the secondary common pathway (Fig. IVa). This cutaneous hyperalgesia can be abolished by denervating the

skin area or locally anaesthetizing it, although pain may still be referred to it. The threshold for appreciating this referred pain is however at a higher level (Doran and Ratcliffe, 1954). The muscular rigidity and the autonomic phenomena of visceral disease are readily explained by simple reflex arcs at a spinal level (Fig. IVb).

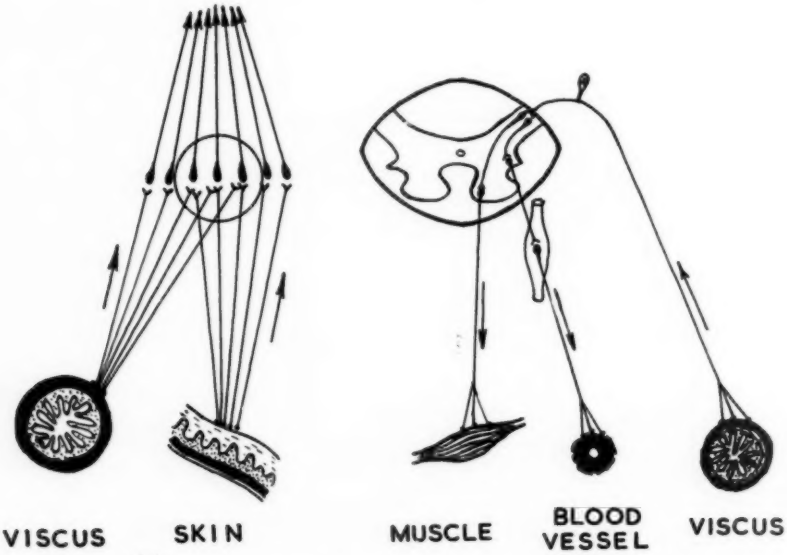

FIG. IV. The neurological basis for other manifestations of visceral disease associated with referred pain.

(a) Cutaneous hyperalgesia. Impulses arising from the diseased viscus lower the threshold for the cutaneous sensory impulses at the common pool of sensory neurones.

(b) Muscular rigidity and vasometer reflexes are caused by the excitement of simple reflex arcs at a spinal level.

SPECIAL TYPES OF VISCERAL SENSATION

Hunger

The physiological basis of this sensation is difficult to assess because the term embraces at least three components, (1) appetite, (2) hunger pangs and (3) the hunger-drive which leads to the search for food (Patton, 1955).

(1) Appetite determines the type of food that is sought and seems to be controlled by the higher cortical centres. It is dependent to a large extent on the establishment of conditioned reflexes built up from previous experiences.

(2) Hunger sensations or pangs tend to determine when and how much we eat and are caused by the contraction of an empty stomach. Adaptation may occur, so that in long fasts although contractions occur, hunger is no longer appreciated. Similar adaptation occurs in the colon if the desire to defaecate is deliberately suppressed. Hypoglycaemia will stimulate hunger contractions, but these are abolished by vagotomy although the desire for food still remains. According to White (1943) hunger pangs are dependent upon the integrity of the vagi but the painful element associated with hunger is probably transmitted by way of the sympathetic afferent pathways. Iggo (1957) has demonstrated that "in series" receptors connected to vagal afferent fibres exist in the muscle wall of the stomach and it is probably these that are responsible for signalling hunger sensations, satiety and the sense of fullness which follows the rapid ingestion of food.

(3) Hunger-drive is not connected with hunger contractions and depends on the integrity of the hypothalamic nuclei, which seem to include both a feeding centre and a satiety centre. The afferent and efferent mechanisms of this hypothalamic system are

unknown but there appear to be glucoreceptors in the ventromedian nucleus (Mayer, 1957). Thus hunger contractions are not essential for the maintenance of caloric balance and neither vagotomy nor gastrectomy seriously affects food intake or food seeking. In vagotomized humans, although hypoglycaemia does not increase hunger contractions it creates a desire for food (Grossman and Stein, 1948) and Dragstedt (1947) confirms that hunger is not abolished by section of the vagi.

Thirst

The regulation of water intake depends on both peripheral and central mechanisms. The dryness of the throat which accompanies thirst is signalled by the sensory fibres in the glossopharyngeal and vagus nerves and these regulate water intake to some extent. In addition a hypothalamic mechanism for water seeking and ingestion has been described by Andersson and McCann (1955) and Miller *et alii* (1957) have shown that, in the rat, satiation receptors exist in the mouth, throat and stomach.

Pain of gall-bladder disease

The pain of biliary disease is produced by inflammation or by distension of the liver-capsule, cystic and common bile ducts. The sensory fibres run in the plexuses along the biliary tracts and are concentrated primarily in the right splanchnic nerve, entering the spinal cord through the seventh, eighth and ninth thoracic segments (White and Sweet, 1955). The pain of gall-bladder disease can usually be abolished by right splanchnicectomy, although in a few cases pain persists in the left hypochondrium but is usually abolished by left splanchnicectomy (White, Smithwick and Simeone, 1952). The distension of the gall-bladder and biliary tracts results in pain referred to the epigastrium and right hypochondrium and the back and if sufficiently intense and prolonged or if the overlying parietal peritoneum is affected this will be accompanied by cutaneous hyperalgesia in the seventh and eighth thoracic segments and overlying muscular rigidity. If the diaphragm is irritated the pain may be referred to the right shoulder tip.

Pain of pancreatic disease

Sensory fibres from the pancreas are carried in the right and left splanchnic nerves and in the coeliac plexus (Rickins, 1945). Clinical evidence suggests that pain from the head is transmitted in the right splanchnic nerve and pain from the tail in the left (White and Sweet, 1955). Afferent impulses caused by calculi with secondary low-grade inflammation and fibrosis or by malignant disease may give rise to pain referred to the epigastrium and back. The pain occurs in waves and presumably arises from back-pressure and distension of the ducts (White and Sweet, 1955). Bilateral section of the splanchnic trunks with removal of the eighth to twelfth thoracic sympathetic ganglia is usually sufficient to abolish the pain, although other authors have obtained only partial or temporary relief from these measures (Cattell and Warren, 1953). Inflammation spreading beyond the capsule of the gland may account for some of the failures. In carcinoma of the pancreas, pain can only be relieved by splanchnicectomy when the carcinoma is confined to the capsule of the gland (White and Sweet, 1955). The residual pain, which may be very severe, is caused by involvement of somatic nerves on the posterior abdominal wall.

Pain of peptic ulcer

Over the years many theories have been propounded to explain the pain of peptic ulceration, the most prominent of which are those of Palmer (1926) and Bonney and Pickering (1946) attributing it mainly to the action of acid on the bare nerve endings; Hurst (1911) who championed the role of gastric motility, and Kinsella (1948) who explained it on the basis of compression of nerve endings by abnormal tissue at the site of the ulcer. The whole subject has been recently reviewed (*Lancet*, 1956) and it seems likely that, depending on variable factors such as the temperament of the individual, the conformation of the ulcer and blood flow, any or all of these factors together with the stimulus provided by chemicals and toxins such as histamine and polypeptides released at the site of the ulcer may be responsible for producing pain. Whether or not pain is produced at a given moment depends on whether the many factors sum to a stimulus great enough to reach the pain threshold for that particular individual at the particular time.

Cardiac pain

Pain fibres for the heart run in the sympathetic afferent fibres of the middle and inferior cardiac nerves and cardiac pain may be abolished surgically by bilateral section of the first to fifth posterior spinal roots or by resection of the upper four pairs of thoracic sympathetic ganglia. When posterior rhizotomy or sympathectomy is unilateral, pain is still referred to one side. After these procedures, although pain is abolished, non-painful sensations such as sense of fullness at the head of the sternum, vasomotor changes in the face and neck, palpitation and dyspnoea still persist. These non-painful sensations are probably carried in the vagi (White, 1943).

Renal tract pain

The afferent fibres from the kidney transverse the renal, aortic and coeliac plexuses, the lowest splanchnic nerves and the rami from the upper lumbar ganglia to enter the spinal cord mainly over the tenth, eleventh and twelfth thoracic spinal roots. Ureteral pain reaches the spinal cord one segment lower down, in the eleventh, twefth thoracic and first lumbar segments (Kuntz, 1953). In addition to the segmental pains of colic, there is a purely visceral, deep-seated fixed or dull pain which more nearly corresponds with the normal anatomical position of the kidney (Kinsella, 1948). Renal pain may be relieved by renal denervation which consists of stripping the renal plexus away from the pedicle and hilum of the kidney (Oldham, 1950). Afferent impulses from the bladder are transmitted along several routes, the principal of which is through the second, third and fourth sacral nerves. Subsidiary pathways also exist along the superior hypogastric plexus and from the lower intercostal and first lumbar nerves which innervate the peritoneal covering of the fundus of the bladder. Pain from the trigone of the bladder is referred to the tip of the penis. White (1943) maintains that although intractable bladder pain may be abolished by bilateral anterolateral cordotomy, the sensation of bladder fullness is still preserved. Yamamoto *et alii* (1956) have shown that impulses travel along the posterior columns in response to bladder distension and these could account for the part preservation of this sensation. However, Nathan and Smith (1951) analysed a series of cases following anterolateral cordotomy and found that after this procedure true bladder sensation was abolished although a vague "substitute sensation" of bladder fullness remained. This may be the type of sensation preserved in the cases described by White. Nathan and Smith concluded that the sensations of bladder fullness, pain from the lower end of the ureters, and pain and temperature from the urethra were conducted in the spinothalamic tracts while the sensations of touch and pressure or tension from the urethra were conveyed in the posterior columns.

SUMMARY

1. Visceral sensations may be classified as
   (i) Visceral pain which is transmitted in the afferent fibres of the sympathetic nervous system and the sacral nerves, S2, 3, 4.
   (ii) Organic sensations, such as hunger, satiety, sense of fullness, etc., which are conducted in the afferent fibres of the vagus and sacral nerves, S2, 3, 4.

   Their pathways in the central nervous system are discussed.
2. The physiology of referred pain, cutaneous hyperalgesia and muscular rigidity in visceral disease is discussed.
3. The physiology of special types of visceral sensation and pain arising from certain organs is considered.

ACKNOWLEDGEMENTS

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CARCINOMA OF THE COLON COMPLICATING ULCERATIVE COLITIS*

By I. S. Russell and E. S. R. Hughes

Royal Melbourne Hospital

WHEN considering the appropriate treatment for a patient presenting with ulcerative colitis, the possibility that this patient will later develop a carcinoma is to be taken into account. To investigate this problem a series of 22 cases has been collected, 11 were obtained by a review of the in-patient records of the Royal Melbourne Hospital from 1954-1959, and 11 are the personal series of one author (Table 1). A distinction has been made between the two groups as it is felt that an assessment of the frequency of this complication based on hospital records may be misleading, as mild cases not requiring admission to hospital will escape inclusion in the series. On the other hand, the personal series of one surgeon including cases of all degrees of severity will be a more reliable guide, although it is true that a surgeon will tend to see the more severe and complicated cases and such a figure will probably represent the upper incidence of frequency.

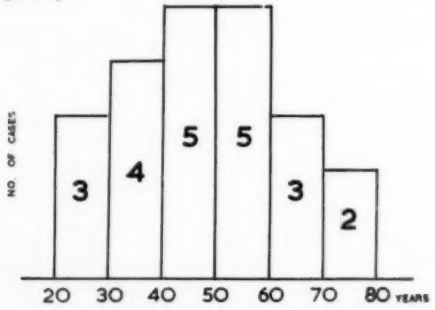

FIG. I. A diagram showing the age distribution of patients presenting with carcinoma superimposed on ulcerative colitis. The average age in the series was 46 years which is significantly lower than in patients presenting with carcinoma alone.

Clinical Features

In this series there were 14 males and 8 females, ranging in age from 24 to 71 years. The average age at onset of colitis was 33 years and the average age at diagnosis of carcinoma was 46 years (Fig. I). The average duration of colitis prior to the development of malignant change was 13 years (mean 13.4, mode 15 years) (Fig. II).

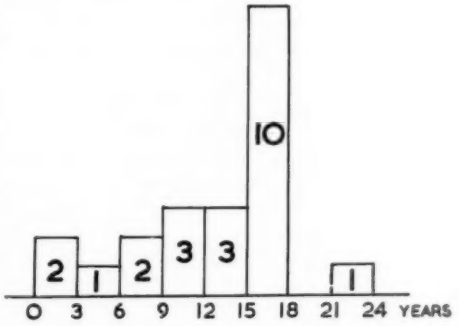

FIG. II. A diagram showing the duration of symptoms of ulcerative colitis prior to presentation with carcinoma. In this series, the average length of history was thirteen years (mean 13.4, mode 15 years).

Pathology

The distribution of the tumours in the colon and rectum is shown in Fig. III. In one instance the patient had 3 primary tumours in the rectum and another had both a carcinoma of the descending colon and a carcinoma of the ascending colon. In 3 instances the tumour developed in the rectal stump remaining after subtotal colectomy.

The tumours were of all macroscopic types seen in the large bowel—stenosing, fungating and ulcerating. Two were anaplastic carcinomata and the others were adenocarcinomata. The neoplasms were highly malignant as judged by local and distant spread. In almost all cases infiltration of all coats of the bowel had occurred although in 9 there was no evidence of distant spread. In 4 patients the neoplasm was inoperable because of extensive local infiltration

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PREVIOUS TREATMENT

In 5 cases the patients had received surgical treatment prior to presenting with a carcinoma.

Two patients had had an ileostomy performed twelve years and eight years before and another had been subjected to subtotal colectomy four months prior to presentation.

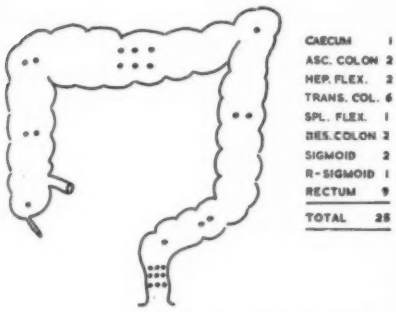

FIG. III. A diagram showing the distribution of tumours occurring in patients forming this series. One patient had both a carcinoma of the descending colon and a carcinoma of the ascending colon and another had three primary neoplasms in the rectum.

Two patients presented with a carcinoma of the rectal stump having had a subtotal colectomy and ileo-rectal (perhaps better classified as ileo-sigmoid) anastomosis performed eight and eleven years before. In one instance the neoplasm was inoperable because of massive local spread and in the other there was lymphatic and hepatic spread and a palliative excision of the rectum was performed.

SURVIVAL

In all instances, the follow-up of the patients in this series has been complete. Seventeen patients have died since operation; 14 succumbed within twelve months of operation, and of these 8 died within the first three months, but the remaining three patients survived, three years, six years and ten years respectively. The three-year survivor died following prolonged medical treatment for aplastic anaemia said to be due to the administration of chloramphenicol. The six-year survivor had no clinical evidence of recurrence when he died at the age of 77 of chronic renal failure due to prostatic obstruction, and the ten-year survivor died following the oversewing of a perforated duodenal ulcer. In none of these 3 longer survivors was an autopsy performed to confirm the absence of any recurrence of the neoplasm.

Five patients are still alive — five months, thirteen months, three years six months, three years nine months, and five years three months after operation. The five-months survivor is known to have secondary deposits in his cervical lymph nodes but the others remain well and have no evidence of recurrence. One of the three-year survivors recently had a cholecystectomy performed for acute cholecystitis, and at operation an opportunity was taken to explore the abdomen and confirm the absence of any recurrence.

DISCUSSION

On occasions patients may be found to have a carcinoma of the colon or rectum when they first present with ulcerative colitis, but the

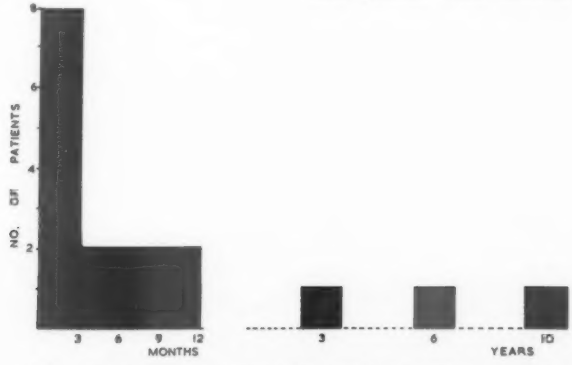

FIG. IV. A diagram showing the length of survival of those patients who have died since operation. Five others are still alive — one five years after operation.

majority are under observation for months or even years prior to the development of a neoplasm. Most patients are seen therefore at a stage when this complication could be prevented if excision of the colon and rectum were performed prophylactically as in familial polyposis coli.

(1950) reported an incidence of 5 per cent. in their series of 2,000 cases. Therefore, if excision of the colon and rectum were performed prophylactically in all patients with ulcerative colitis, it would be unnecessary, as far as the prevention of carcinoma is concerned, in 19 out of 20 cases.

TABLE 1

Case	*Sex*	*Age*	*Duration of colitis*	*Previous treatment*	*Site of tumour*	*Spread*	*Treatment of neoplasm*	*Outcome*
1	M	63	10 yrs.	—	Trans. colon	Peritoneum omentum	Laparotomy	Died 2 weeks
2	M	56	13 yrs.	—	Caecum	Local, glands, liver, peritoneum	Laparotomy	Died 2 weeks
3	M	29	17 yrs.	—	Asc. colon Desc. colon	Glands	Procto-colectomy	Alive 5 mths. glands in neck
4	F	30	15 yrs.	Subtotal colectomy 4 months	Rectal stump	Local	Excision of Rectum	Died, recurrence 9 months
5	F	31	16 yrs.	Ileo-sigmoidostomy 11 years	Rectal stump	Local	Nil	Died 3 weeks
6	F	54	10 yrs.	—	Rectum	Liver peritoneum	Excision of rectum	Died 3 weeks
7	F	56	15 yrs.	—	Desc. colon	Nil	Procto-colectomy	Alive 5 yrs.
8	F	62	10 yrs.	—	Trans. colon	Nil	Procto-colectomy	Alive 3½ yrs.
9	F	47	7 yrs.	—	Trans. colon	Nil	Procto-colectomy	Alive 3½ yrs.
10	F	37	14 yrs.	—	Asc. colon	Glands	Colectomy and ileo-rectal	Died, recurrence 7 months
11	M	56	15 yrs.	Ileostomy 8 yrs.	Rectum (3 tumours)	Glands peritoneum	Excision of rectum	Died, recurrence 10 months
12	M	30	12 yrs.	Ileo-rectal 8 yrs.	Recto-sigmoid	Glands, liver	Ileostomy	Died, recurrence 1 month
13	M	50	21 yrs.	—	Splenic flex.	Local peritoneum	Laparotomy	Died, recurrence 1 month
14	M	29	15 yrs.	—	Rectum	Local	—	Died, 3 days after admission
15	F	46	14 yrs.	—	Trans. colon	Nil	Procto-colectomy	Died, recurrence 8 months
16	M	42	15 yrs.	—	Rectum	Nil	Procto-colectomy	Died, recurrence 4 months
17	M	70	5 yrs.	—	Trans. colon	Nil	R. hemi-colectomy	Died, 3 weeks renal failure
18	M	48	16 yrs.	—	Desc. colon	Nil	Sub-total colectomy	Died, 3 years aplastic anaemia
19	M	64	1 month	—	Trans. colon	Nil	R. hemi-colectomy	Alive and well 13 months
20	M	71	No History ?	—	Rectum	Nil	Excision of rectum (colon excised 2 years later)	Died, 6 years renal failure
21	M	42	17 yrs.	—	Hepatic flex	Local	R. hemi-colectomy	Died, recurrence 5 months
22	M	24	16 yrs.	Ileostomy 1 yr.	Trans. colon	Nil	Subtotal colectomy ileo-rectal	Died 10 years perforated ulcer

The difficulty in assessing the frequency of this complication from hospital series has been stressed. We have therefore based our estimate on the series of private patients. In this group there were 272 patients in whom a diagnosis of ulcerative colitis was established and of those 11 developed a neoplasm. This represents an overall incidence of 4 per cent. (Table 2).

TABLE 2

INCIDENCE OF CARCINOMA IN ULCERATIVE COLITIS

No. of cases — — — —	272
No. of patients with carcinoma	11
Overall incidence — — —	4 per cent.

These figures are comparable with other published series. Dawson and Pryse-Davies from the Gordon Hospital (1959) in a review of 663 patients reported an overall incidence of 3 per cent. Goldgraber *et alii* (1958), in a series of 792 patients, found an incidence of greater than 3 per cent. and Sloan *et alii*

On the other hand, once this complication occurs, the prognosis is extremely poor. Slaney and Brooke (1959) in a review of the literature collected 304 patients with carcinoma of the colon complicating ulcerative

colitis. Only 13 survived for five years and, of those, three have since died of carcinoma. In our series only 3 patients survived for more than five years although of 19 patients reported by Morson *et alii* (1960) 6 survived for five years.

In view of this high mortality, is it possible then to select those patients most likely to develop a carcinoma? One outstanding fact is that this complication tends to occur in patients with long-standing disease. The average duration of colitis in this series was thirteen years, 17 of the 22 patients having had colitis for ten years or more. In the private series, 40 of the 272 patients had colitis for ten years or more and of those 10 developed a carcinoma. Only one of the remaining 232 patients who had colitis for less than 10 years developed a carcinoma and she had had colitis for seven years (Table 3).

TABLE 3

INCIDENCE OF CARCINOMA IN 272 PATIENTS

Colitis for longer than 10 years	40
Carcinoma	10
Colitis for less than 10 years	232
Carcinoma	1

One other guide has been suggested. It has been stated that those patients who develop colitis early in life are more prone to develop a carcinoma (Jackman, 1940). In our series this could not be confirmed.

Patients with colitis of 10 or more years' standing have therefore a high risk of carcinoma which has been estimated by Cattell (1948) to be 33 per cent. and by Counsell and Dukes (1952) to be 50 per cent., and which in this series is 25 per cent. For this reason, it has been suggested that patients in this category should be kept under particularly close observation so that if a carcinoma develops it will be detected at an early stage. Despite this, patients with this complication tend to present with an advanced tumour, as judged by local and distant spread, for two main reasons. First, the neoplasm itself tends to be highly malignant, to metastasize early and to be locally invasive rather than proliferative. Secondly, the symptoms of colitis may mask the symptoms of a developing carcinoma. Changes of bowel habit, abdominal distension and colicky pain may all be attributed to ulcerative colitis both by the patient and by his doctor.

FIG. V. A photograph of the barium enema from Case 3. It will be seen that there is a filling defect due to a carcinoma of the descending colon, and that there is no radiological evidence of ulcerative colitis.

Case 1

Mr. R., aged 63, had a history of ulcerative colitis of ten years' duration when a carcinoma of the colon was detected. He had been observed regularly over the preceding seven years at the Royal Melbourne Hospital and treated medically. However, at laparotomy he was found to have an inoperable carcinoma of the transverse colon.

Case 2

Mr. H. first developed ulcerative colitis in 1945 when he was 43 years of age. Over the following thirteen years he was under the care of two highly competent physicians. Repeated barium enemas were performed in 1945, 1953 and in 1958, none of which showed any evidence of a neoplasm. However, six weeks after his last X-ray, he developed obstructive jaundice, and laparotomy revealed an inoperable carcinoma of the caecum with local, peritoneal, lymphatic and hepatic spread.

This series has therefore confirmed the high incidence of carcinoma in patients with a long history of colitis and indicated that, although

special care is taken with patients in this high-risk group, it is almost impossible to detect the early carcinoma. Even at operation it can be difficult to detect a small tumour (Dukes and Lockhart-Mummery, 1957), and therefore, when the colon is resected for carcinoma superimposed on ulcerative colitis, the entire colon should be removed with high pedicle ligatures as these tumours tend to be multiple.

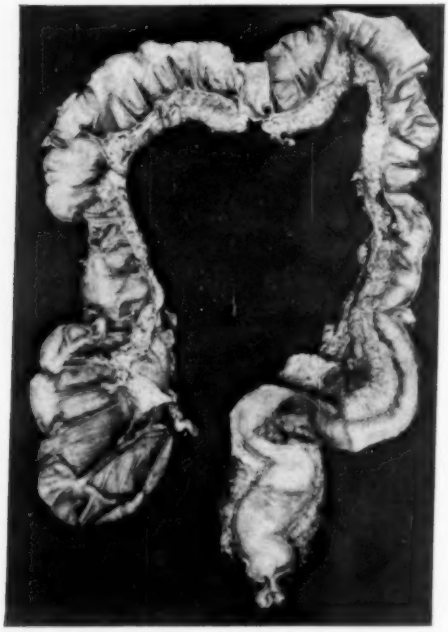

FIG. VI. A photograph of the operation specimen from Case 3. The carcinoma of the descending colon detected by the barium enema may be seen, and in addition there is a small neoplasm of the ascending colon which was not observed at laparotomy and which is difficult to detect even on opening the specimen. The rest of the bowel has the typical appearance of a mild ulcerative colitis (cf. Fig. V).

Case 3

Mr. R. was treated at the Children's Hospital at the age of 12 for ulcerative colitis, and at that time was warned of the possibility that he might later develop a carcinoma. He remained well for a number of years, and then presented at the age of 29 with a twelve months' history of diarrhoea with blood and mucus which he had attributed to a recrudescence of his colitis. A barium meal (Fig. V) revealed a carcinoma of the descending colon and excision of the colon and rectum was performed. On opening the operation specimen (Fig. VI) it became apparent that, in addition to the carcinoma of the descending colon, he had a carcinoma of the ascending colon which had not been detected either by barium enema or at laparotomy.

If colectomy is to be advised in this group of patients with long standing disease, the question arises as to whether the rectum can be preserved and operation made more acceptable to the patient by the construction of an ileo-rectal anastomosis and avoidance of an ileostomy.

The leading protagonist of ileo-rectal anastomosis is Aylett who recently reviewed 120 cases treated by ileo-proctostomy (1959a). In one instance (a boy aged 19 who had suffered from colitis since the age of 2) the rectal inflammation failed to resolve after total colectomy and he ultimately developed an advanced carcinoma in the rectal stump. In a subsequent letter to the Lancet (1959b), Aylett stated that if the disease developed in a young patient and had been present for a long time, he thought that removal of the rectum would be safer.

Slaney and Brooke (1959, 1960) have since collected 5 similar cases from the literature and in our series 2 patients developed inoperable carcinomas of the rectal stump.

Case 4

Mrs. Y., 30 years of age, presented with ulcerative colitis of fifteen years' duration. It was decided to perform a two-stage procto-colectomy. At the initial operation a sub-total colectomy and ileostomy was performed, and the patient was readmitted to hospital for the second stage four months later. On this admission she was found to have developed an advanced carcinoma of the rectum.

Case 5

Mrs. W., 31 years of age, had suffered from ulcerative colitis from the age of 15. When 20 years old, sub-total colectomy and ileo-sigmoid anastomosis was performed. The surgeon's reluctance to condemn a young girl to permanent ileostomy can well be appreciated. However, eleven years later—two weeks after giving birth to a child—she was admitted to hospital with an inoperable carcinoma of the rectum.

In assessing the risk of leaving the rectum *in situ* and performing ileo-rectal anastomosis several facts have to be considered.

1. The rectum is involved in the inflammatory process in 95 per cent. of all cases and is commonly the site of neoplastic change. In this series the neoplasm was situated in the rectum in 7 out of 22 cases and in Morson's series in 8 out of 19 patients.

2. It is suggested that following colectomy the changes in the rectal mucosa will subside. However, this does not always happen, as illustrated by Aylett's case reported above.

3. Even if the inflammatory changes do subside it is still possible that a neoplasm will develop. Morson *et alii* (1960) reported that in every surgical specimen of carcinoma complicating ulcerative colitis examined at St. Mark's Hospital, the intestinal mucosa had the macroscopic and histological appearance of a healed ulcerative colitis (cf. Fig. VI).

4. The development of a neoplasm in the rectal stump may be delayed for many years after colectomy, for example in Case 5 the tumour developed eleven years after ileo-proctostomy. Although it is true that few instances of this complication have been reported so far, it is possible that as time elapses and this operation is performed more frequently, more cases will be reported.

Clearly it is not possible at present to define the place of ileo-rectal anastomosis in the treatment of ulcerative colitis and only the passage of time will clarify this problem.

CONCLUSION

1. This series confirms that carcinoma of the colon supervening on ulcerative colitis has a grave prognosis.

2. This complication occurs in 4 per cent. of all cases of ulcerative colitis and in 25 per cent. of those with colitis of ten or more years' standing.

3. The carcinoma is usually advanced by the time it is discovered even although a careful watch is maintained.

4. When the colon is resected for carcinoma superimposed on ulcerative colitis, the entire colon should be removed as small tumours cannot be felt at operation.

5. Whether or not ileo-rectal anastomosis can be safely advocated will depend on the results of present investigations but these will require the passage of considerable time before a conclusion can be reached.

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VOLVULUS OF THE BOWEL*

By J. Ryan

Staff Radiologist, Royal Prince Alfred Hospital, Sydney

IN the Royal Prince Alfred Hospital there have been 27 cases of volvulus of the bowel between 1953 and 1959. Eleven occurred in the small bowel, 5 in the caecum, one in the transverse colon and 10 in the sigmoid colon. The mortality rate in the cases of volvulus of the small bowel has been high, 7 deaths out of 11 cases. Two of the 16 cases of large bowel volvulus died.

The prognosis of volvulus is bad in comparison with other forms of intestinal obstruction due to delay in establishing the diagnosis. If effective treatment is not carried out early in the course of the condition, simple torsion becomes strangulation, with venous and later arterial occlusion and superimposed gross gaseous distension in a closed loop of bowel (Aird, 1950; Gerwig, 1950). The diagnosis may be missed owing to the infrequency of volvulus as a cause of bowel obstruction.

Almost all cases of volvulus may be diagnosed by X-ray, usually on plain films of the abdomen. A barium enema is required occasionally to make the diagnosis certain. When this is considered necessary, the enema should be performed without delay (Frimann-Dahl, 1951; Rigler and Lipschultz, 1940). There is very little danger of rupture of the bowel by the use of a barium enema, whereas delay in diagnosis may be fatal.

The object of this paper is to review 4 cases from this hospital which show the radiological features by which the diagnosis of volvulus may be made.

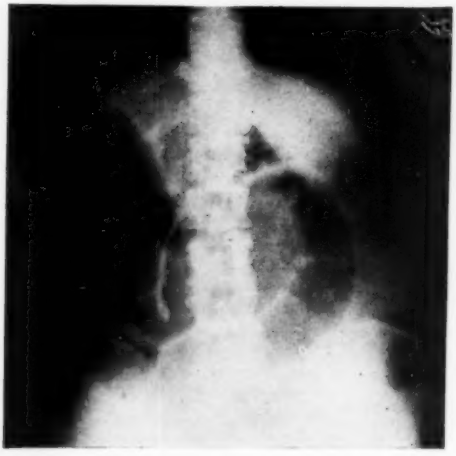

FIG. I. Small bowel volvulus (supine film).

FIG. II. Small bowel volvulus (vertical film).

Case Reports

Case 1 — Small bowel volvulus

R.M., female aged 59 years, was admitted, with severe abdominal pain and vomiting of 24 hours duration, in a severely shocked state. Physical examination showed abdominal distension, with resonance only in the upper right quadrant. There was no tenderness. Bowel sounds were present but diminished. The blood pressure could not be recorded. Despite intensive resuscitative measures she died six hours after admission. Post-mortem showed

*Received for publication 24th May, 1960.

volvulus of the distal half of the jejunum and the ileum, with strangulation of the involved bowel.

Plain X-rays of the abdomen showed small bowel volvulus (Figs. I and II). Features in these films are:

(i) the whorled arrangement of the walls of the gas-filled loops of bowel;

(ii) widely scattered fluid levels, varying in size, and at different levels;

(iii) the length of the fluid levels, greater than those usually seen in simple obstruction;

(iv) lack of distension of the large bowel, and

(v) the presence of free intraperitoneal fluid, shown by the separation of the bowel walls by fluid and by the dense opacity in the pelvis in the vertical film.

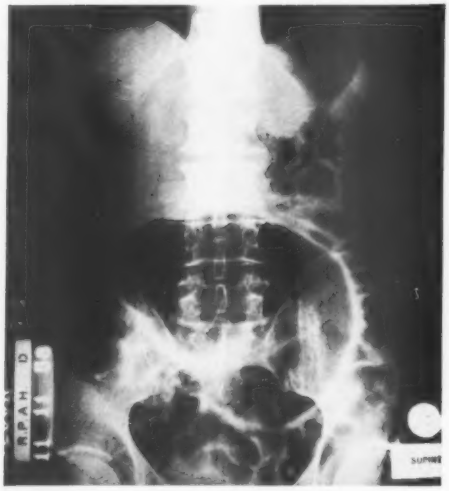

FIG. III. Caecal volvulus (supine film).

Case 2 — Volvulus of the caecum

G.D., male aged 74 years, complained of abdominal pain for twenty hours before admission. The pain was of sudden onset, not colicky and gradually getting worse. The pain was most severe in the lower abdomen. There had been some vomiting and his bowels had opened twice, with loose motions. Physical examination showed hypogastric distension, with suprapubic rebound tenderness.

Plain films of the abdomen showed volvulus of the caecum (Figs. III and IV). The diagnostic features in these films are:

(i) the distended caecum occupying the lower abdomen;

(ii) the curved walls of the caecal loop which converge towards the right iliac fossa;

(iii) gas in the small bowel, which is displaced downwards, to the left and towards the left hypochondrium;

(iv) the large caecal fluid level, with few fluid levels in the small bowel, and

(v) the empty colon distal to the caecum.

These films demonstrate early caecal volvulus. As the condition progresses, there is increasing distension of the caecum, which rises towards the left hypochondrium and may come to occupy most of the abdomen. The appearances of small bowel obstruction are added.

Case 3 — Volvulus of the transverse colon

R.J., male aged 31 years, presented complaining of continuous abdominal pain of ten hours duration, constantly present but with colicky exacerbations. There had been some vomiting at the onset and he had passed one loose motion.

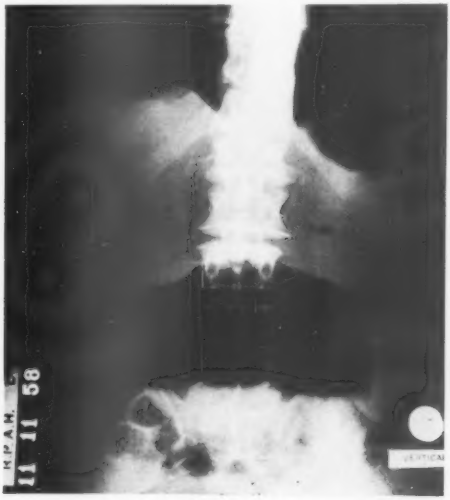

FIG. IV. Caecal volvulus (vertical film).

Physical examination revealed generalized tenderness and rigidity, maximal in the umbilical region and towards the epigastrium. There was also an area of resonance in this region.

Plain X-ray of the abdomen and later barium enema showed volvulus of the transverse colon (Figs. V and VI — plain X-rays; Figs. VII and VIII — barium enema studies). Features of note in the plain rays are:

(i) a single dilated loop of transverse colon;

(ii) a single long fluid level;

(iii) empty large bowel distal to the site of volvulus;

(iv) no evidence as yet of distension of the small bowel or of the colon proximal to the volvulus, and

(v) radio-opaque material outlining the stomach, due to previous medication.

The films taken during barium enema performed twenty-four hours later show:

(i) the characteristic curved, beak-like contour of the barium as it reached the volvulus;

(ii) no barium entered the distended loop, nor did it pass beyond the point of torsion;

(iii) increasing distension of the large bowel proximal to the volvulus, in comparison with the plain rays, and

(iv) the redundant large bowel is shown outlined with barium.

Operation revealed the volvulus of the transverse colon associated with developmental malrotation of both small and large bowel.

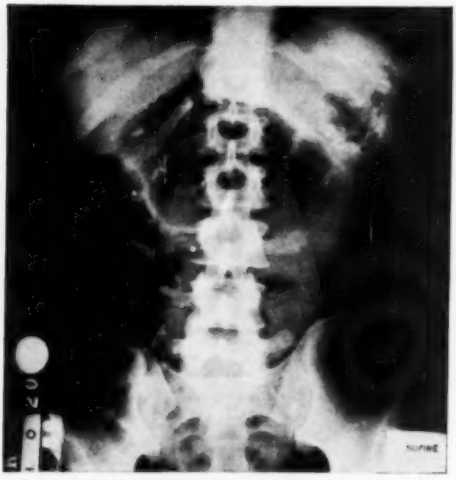

FIG. V. Volvulus of transverse colon. Plain film in supine position.

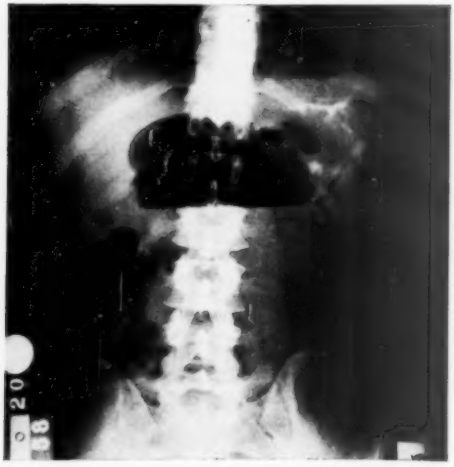

FIG. VI. Volvulus of transverse colon. Plain film in vertical position.

FIG. VII. Volvulus of transverse colon. Barium meal study (supine).

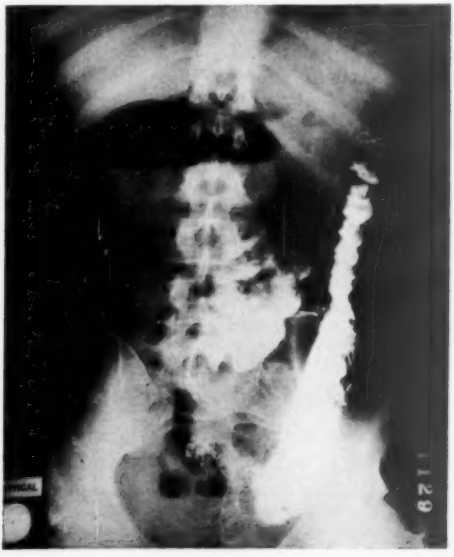

FIG. VIII. Volvulus of transverse colon. Barium meal study (vertical).

Case 4 — Volvulus of the sigmoid colon

L.T., female aged 80 years, complained of severe colicky pain in the hypogastrium for 2 days before admission, with absolute constipation for thirty-six hours. Physical examination showed marked abdominal distension with hyperresonance to percussion over the abdomen. The bowel sounds were diminished. There was neither tenderness nor guarding. No mass was palpable. Plain X-rays of the abdomen showed volvulus of the sigmoid colon (Figs. IX and X). The diagnosis was based on the following features:

FIG IX. Volvulus of sigmoid colon. Film in supine position.

FIG. X. Volvulus of sigmoid colon. Film in vertical position.

(i) marked gaseous distension of the sigmoid colon, which is seen rising out of the pelvis;

(ii) the walls of the dilated bowel converging upon the point of volvulus within the pelvis;

(iii) fluid levels in the vertical film. These fluid levels would have been more obvious in a film taken in the lateral recumbent position, with horizontally directed rays;

(iv) no gas is seen in the rectum, and

(v) the high subdiaphragmatic position of the affected loop of bowel.

DISCUSSION

The incidence of volvulus causing bowel obstruction is variously reported, from 2 per cent. (Figiel and Figiel, 1959) to 10 per cent. (Wangensteen, 1937) to 40 per cent. (Becker, 1953). A differing incidence is recorded by Gerwig (1950), who states that volvulus is responsible for 40 per cent. of bowel obstructions in Europe and for 7 per cent. in the United States of America. In Europe, the ratio of small bowel volvulus to large bowel volvulus is 1 to 3, whilst the incidence in the United States is 57 per cent. small bowel and 43 per cent. large bowel volvulus. In the present small series, the small bowel undergoing torsion in 40 per cent., suggesting that the incidence in Australia may lie between European and American figures. Whether the influx of a new population from Europe will affect these proportions remains to be seen. In the present series, all patients were Australian residents. The incidence of colonic volvulus as reported in American and European literature is caecum, 10; transverse colon, 1; sigmoid colon, 20 (Buckstein, 1953; Frimann-Dahl, 1951; Gerwig, 1950). The present series follows the same pattern.

Volvulus occurs only in a freely mobile bowel. Additional predisposing or contributory causes are large residue, bulky diets, trauma, severe exertion, excessive purgation poor bowel habits, tumour of the bowel and

pregnancy. The importance of these various factors is debated (Rothman *et alii*, 1943; Bruusgaard, 1942; Aird, 1950).

The diagnosis of volvulus may be made in most cases, if radiology is used to support a high index of suspicion. Several films are necessary for accurate diagnosis, particularly in small bowel volvulus, where the radiological appearances in a single film may mimic acute vascular occlusion (Samuel, 1954). Multiple scattered fluid levels in small bowel are seen in the vertical films in both conditions without a pattern of distribution, but demonstration of the volvulus in the supine film is diagnostic. Acute vascular occlusion gives an irregular distribution of the fluid-filled loops in all films. Apart from this, there is no differential diagnosis, even in early cases, when adequate films of adequate quality are available.

SUMMARY

The diagnostic features of volvulus of the bowel are presented by describing 4 cases showing the typical radiological signs.

All have some signs in common, which are here listed:

There is gaseous distension, which is usually marked.

Few fluid levels are seen, and these are longer than those seen in other forms of obstruction of the bowel.

The bowel proximal to the torsion shows distension, and the distal bowel is empty.

The curved lines of the wall of the affected bowel converge towards the site of volvulus.

These characteristic signs appear early in the condition and are diagnostic. Usually plain X-ray of the abdomen is sufficient to give the diagnosis. Barium enema is occasionally necessary and should be used whenever idicated.

ACKNOWLEDGEMENTS

I wish to thank Dr. Alan R. Colwell, Director of Radiology and Associate Professor Milton for their help in the preparation of this paper.

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Books Reviewed

ST. PETER'S HOSPITAL FOR STONE, 1860-1960.

By CLIFFORD MORSON, O.B.E., F.R.C.S. Edinburgh and London: E. & S. Livingstone Ltd., 1960. 9¼" x 7½", 64 pp., 18 illustrations. Price: 21st. (stg.).

This book is a history of the Hospital issued on the occasion of its Centenary.

The author has himself been a surgeon on the staff of St. Peter's for many years. The book is a concisely written history of some 63 pages with numerous illustrations and photographs of ex-members of the staff.

It is divided into sections — the history of the hospital, a chapter on the committee of management, one of biographies of deceased members of the surgical staff, one on the ancillary services of the hospital, the venereal diseases department, and the nursing staff. It concludes with a complete list of past and present members of the staff, resident surgical officers, anaesthetists, etc.

This book is in no sense a textbook on urology, but will be of very considerable interest to the many Australian surgeons who have attended the hospital or been on its resident staff during the course of their post-graduate training.

It is, in a sense, a history of a major part of English urology and can be thoroughly recommended as entertaining reading, especially by those surgeons having an interest in the history of surgery generally.

THE STURGE-WEBER SYNDROME.

By G. L. ALEXANDER and R. M. NORMAN. Bristol: John Wright & Sons Ltd., 1960. 9¼" x 6½", 95 pp., 54 illustrations. Price: 32s. 6d. (stg.).

This monograph is dedicated to Dr. Parkes Weber in his ninety-seventh year. It is fitting that the authors are from Bristol where William Alan Sturge was born in 1850.

In 1879 Sturge showed a patient with hemiparesis, epilepsy, a facial naevus and buphthalmus. He maintained that the neurological component of the syndrome was due to a naevoid condition of the brain akin to that of the patient's face.

The Sturge-Weber's syndrome is characterized by cutaneous angiomatosis of the face, epilepsy, gyriform calcification, and, in some cases, buphthalmus or glaucoma. Mental retardation is usual, hemiparesis of the side opposite the facial naevus is common, and hemianopia is a feature.

The essential pathological features are the facial naevus and angiomatosis of the leptomeninges. This angiomatosis is a dense felt-work of small vessels. Calcification in the underlying brain appears to be secondary to the angiomatosis.

The monograph contains reports of seven cases, five of whom were subject to lobectomy. This operation was usually an occipito-parietal lobectomy, but, in one or two cases, was more extensive.

A short chapter is devoted to radiological aspects, and it is stated that the distinctive gyriform shadows are due to massive concretions, which have replaced parts of the cortical grey matter. The double contoured appearance is due to calcification in opposing gyri. Electro-encephalography and electro-corticography was done, and part of a general comment made by Dr. Grey Walter was as follows: "In those cases displaying focal abnormal discharges rather than reduction in rhythmic activity, it must be supposed that the effect of the lesion was mainly to isolate, rather than to destroy the nervous tissue involved, the naevus in these cases behaving rather like a subcortical tumour."

A neuro-pathological study was made of the angiomatosis and the cerebral calcification. This chapter contains several interesting photographs.

There is an interesting chapter in which the distribution of the facial naevus is discussed in relation to development. Epilelpsy, which is present in almost every case of the Sturge-Weber anomaly, usually brings the patient first to the notice of the clinician. There seems no doubt that from this time onwards there is a noticeable deterioration in intellect. In most cases the first convulsions are observed in the first two years of life. The history of patients with this disease is usually one of admission to an institution and of death in status epilepticus at an early age.

From the evidence presented in this monograph, lobectomy would seem to offer a chance of forestalling or modifying epilepsy, and possibly of affecting paresis and intellectual retardation.

The authors are to be congratulated on producing such a readable and compact study of the subject, and they do a great service in bringing to our attention the value of surgery in these cases. The monograph includes a comprehensive reference which would be of great value to anyone making a further study of this subject.

DISC LESIONS AND OTHER INTERVERTEBRAL DERANGEMENTS.

By E. J. CRISP. Edinburgh and London: E. & S. Livingstone Ltd., 1960. 8½" x 5½", 156 pp., 48 illustrations. Price: 15s. (stg.).

The author is Consultant Physician Emeritus in Physical Medicine at Guy's Hospital, London. This is a condensed book and is well illustrated by line drawings and gives a general account of spinal disease and injuries throughout the whole length of the spinal column that may be improved by conservative means of treatment—mainly immobilization, manipulation and traction. This straightforward and useful work does not deal with the surgical treatment of lumbosacral pain and sciatica. The lumbar, dorsal and also the cervical spine is dealt with systematically, if briefly. In the cervical spine more reliance is placed on traction than any other method "though its modus operandi may be somewhat speculative" although manipulation is not completely frowned upon because this is fully illustrated by 5 drawings. Apparently anaesthesia is not used for spinal manipulations at any level because "if the patient cannot relax or muscle spasm is intense manipulation is contra-indicated although traction may well be permissible."

FUNDAMENTAL TECHNIQUES IN PLASTIC SURGERY AND THEIR SURGICAL APPLICATIONS.

By IAN A. McGREGOR. Edinburgh and London: E. & S. Livingstone Ltd., 1960. 8½" x 5½", 244 pp., 150 figures. Price: 30s. (stg.).

It would be difficult to overestimate the importance of this new work, not only in the training of young plastic surgeons but also as a reference work to those engaged in the practice of general surgery, who have occasion, from time to time, to make use of the simpler techniques and less complicated devices of plastic surgery. Every plastic surgeon has long regretted the absence of a book which gets down to fundamentals and at the same time simplifies the teaching of surgical principles in the speciality. The process of trying to extract such material from the larger and more complex works on plastic surgery is a tedious one and one which is of little help to the beginner because of the absence of discrimination between the good and the bad and because of the tendency to describe operations without enunciating principles.

This book, in which can be seen the influence of one of the premier plastic surgery units in Great Britain, fills the gap admirably. It is not too big. It includes all the common problems and major principles and is set out in easily assimilable form. It is divided into two main sections, of which part one, which deals with principles and basic techniques, is by far the better and more important. Part two deals with certain applications of method to problems in different fields of surgery and as such, it can only be very limited in its scope in a small volume such as this. The photographic illustrations are of excellent quality and the line drawings clear, simple and accurate. In short, the book fulfils a longstanding need in relation to the basic teaching of plastic surgery and will receive the blessing of plastic surgeons the world over. The author is to be complimented on achieving something unique in its field and the publishers on the quality of production.

ARTERIAL EMBOLISM IN THE LIMBS.

By I. DUNSFORD and JEAN GRANT. Edinburgh: Oliver & Boyd Ltd., 1959. 8½" x 5½", 120 pp., xi tables, 9 figures. Price: 12s. 6d. (stg.).

The author critically examines and evaluates every facet of the problem of arterial embolism in the limbs, in the light of his personal experience of 81 patients seen over the space of some sixteen years.

The clinical features and results of treatment in his own personal series are the subject of detailed analysis which is very clearly represented.

An excellent feature of the book is the final chapter in which are summarized the author's main conclusions drawn from an assessment of all this and other data.

These conclusions and the evidence on which they are based, are a most authoritative contribution to our knowledge of the clinical manifestations, prognosis and management of arterial embolism.

Dr. Jacobs is to be congratulated on this excellent book which should be studied by all to whom the clinical problem presents — the physician treating the cardiac condition and the surgeon who is consulted concerning the propriety of embolectomy.

THE CELL OF SCHWANN.

By GILBERT CAUSEY, M.B., F.R.C.S. Edinburgh and London: E. & S. Livingstone Ltd., 1960. 8½" x 5½", 276 pp., 40 illustrations. Price: 21s. (stg.).

This monograph commences appropriately with a short biography of Theodor Schwann (1810-1882). Many will be interested to learn that Schwann produced two far-reaching and fundamental ideas; firstly, that the processes of alcoholic and putrefactive fermentation were due to living organisms, and secondly, a carefully prepared volume concerning the cellular structure of plants and animals. Schwann's observations influenced Pasteur, who wrote to him saying, "For twenty years past I have been travelling along some of the paths opened up by you." It is clear from this short biography that the examination and description of the Schwann cell formed but a small part of his discoveries and his examination of the cellular units of plant and animal tissue.

Professor Causey goes on in succeeding chapters to show the importance of the cell of Schwann in relation to present views of myelination, regeneration and neoplasms of nerves. The structure of a peripheral nerve trunk has been investigated with the aid of the electron microscope and several excellent micrographs have been reproduced.

One cannot summarize the arguments put forth in these informative chapters. There is a major difficulty in deciding where the boundary lies between the epi- and the perineurium, and, again, to decide how much of the endoneurial packing is derived from Schwann cells and how much from fibroblasts. The electron microscope has extended the scope of histological investigation and has helped to clarify the relationship between the Schwann cell and the nerve fibre, and the Schwann cell and the surrounding sheaths.

The author and his associates prepared complete transverse sections of peripheral nerves for electron microscopy and were impressed with the scarcity of fibroblasts inside the perineurium. This suggests that the structures inside the perineurium are nerve fibres with Schwann cells and that the only other elements are small blood vessels with endothelial cells and a few fibroblasts. It is considered that the Schwann membrane is part of the protoplasm of the Schwann cell, while the endoneurium forms the collagen and reticulin sheath. In this thesis the perineurium becomes the limiting region between the mesodermal and the neurectodermal structures. The myelin sheath has been studied with regard to its division by the nodes of Ranvier, its chemical and physical structure, and the relationship of its thickness to the size of the axon which it surrounds.

The ultra structure of the Schwann cell is beautifully illustrated in the electron micrograph. The electron microscope has shown that in the peripheral nerves the axis cylinder is within the cytoplasm of the cell of Schwann, but is separated from the cytoplasm by ultra microscopic membranes; this is a new concept. Any cell which enfolds the nerve fibre within its cytoplasm is a Schwann cell.

The development and tissue culture of Schwann's cells forms an interesting chapter where the findings of many workers are reviewed. It is mentioned that there are no Schwann cells in the central nervous system, but many workers have remarked on the

similarities between the supporting cells related to peripheral nerve fibres and among other nerve fibres in the central nervous system. Some would prefer to use the term "satellite cell" to cover the whole group of perineuronal cells. The intimate relationship between the cells of Schwann and the processes of degeneration and regeneration in nerves is clearly described, and various theories are examined. Neoplasms of Schwann cells form the subject of a short description in relationship to the group of tumours which begin their growth within the sheath of a peripheral nerve. The different views of their nature and origin are discussed.

The monograph stresses the close structural and functional relationship of the Schwann cell to the axon. It clearly illustrates the fact that normally there is a cytoplasmic discontinuity between the Schwann cytoplasm and the nerve fibre. Professor Causey states that further studies are required to learn of the metabolism and pharmacology of the Schwann cells, and that this may lead to a better understanding of the ionic and electrical changes in mammalian nerves. Again, a close similarity is suggested between the peripheral and the central nervous system, if the perineuronal cells, including the Schwann cell, are looked upon as satellites.

The monograph is full of stimulating ideas; for example, demyelinating diseases may become better understood from studying the Schwann cell and its formation of myelin. It is an extremely valuable addition to the literature, and should be read by all who are interested in the structure of peripheral nerves and the phenomena of their degeneration and regeneration.

OSTEOCHONDRITIS DISSECANS : LOOSE BODIES IN JOINTS : ETIOLOGY, PATHOLOGY, TREATMENT.

By I. S. SMILLIE. Edinburgh and London: E. & S. Livingstone Ltd., 1960. 10" x 6½", 223 pp., 228 illustrations. Price: 60s. (stg.).

Here the author deals with a subject of unknown causation and with the experience of observing 300 cases, carefully studies the pathology and puts forward a method of treatment in selected patients — internal fixation of the detached fragment by a pin that is removed later. In the general section the author sees at least one cause which is an irregularity or anomaly of ossification of the epiphysis caused by a local deficiency of the blood supply at the end of the first decade — the juvenile as opposed to the adult form of osteochondritis dissecans. This may explain bilateral disease in the lower end of the femur and elbow joints. The argument is not so simple and the problem becomes complex involving other factors such as trauma, especially in the adult variety, endocrinology and familial influences. Individual joints are then considered with emphasis on the knee — medial and lateral condyles and the patella. In early cases the treatment is conservative. But the results where the author had followed up cases in which a large loose body consisting of a large weight-bearing surface of the femoral condyle had been removed were such that he has proposed paring down the loose body to fit into the crater with internal fixation by a special nail. This has a groove around the head so that it can be gripped by a long, narrow-ended dental forceps for removal later. The instruments and technique for this operation are described in detail for the knee. The results of the operation in 30 patients are shown. The method is also used for the talus in a recent "dome" fracture with displacement or for osteochondritis dissecans at the lateral angle of the articular surface of the talus through a lateral approach after osteotomy of the fibula. The book is clearly written and beautifully illustrated. The method in suitable cases appears to have merit and can hardly be harmful. But the second operation for removal of the nail appears to be a necessary evil.

A TEXTBOOK OF SURGICAL PHYSIOLOGY.

By R. A. JAMIESON and A. W. KAY. Edinburgh: E. & S. Livingstone Ltd., 1959. 10" x 6½", 623 pp., 186 illustrations. Price: 55s. (stg.).

Mr. Ainslie Jamieson and Professor Andrew Kay in their "Textbook of Surgical Physiology" have made a valuable addition to British surgical literature, which will do much to free the thought of surgeons from formalized anatomy and introduce a dynamic flux gained by a study of the physiology and experimental pathology of disease processes. In the compass of 600 pages a wide survey of the background of surgery may be found systematically presented. The chapter titles range from wound healing and the biological effects of irradiation to a discussion of the functions of the ureter and the results of ureteric surgery in man and the experimental animal. The text is well illustrated with graphs, line drawings and photographs where these are necessary to amplify the text.

Each subject considered is treated with consummate care and each chapter brings something fundamental into the clinical context. The result of this is to add point to many of the practices of surgery. Scientifically the approach is excellent. The authors always seek information from clinical observation before appealing to animal experiment for assistance, for example "there has been no opportunity to intubate the healthy gall-bladder. For a complete study it is therefore necessary to rely on animal experiment" (page 502). This attitude would appear to be entirely correct and commendable. It also illustrates once again how forethought in planning operative treatment can be turned to good scientific account by subsequent observations.

To read that "recently it has been possible" to perform a manoeuvre like transplenic portography — now an established technique, tends to date a book at the very moment of its publication. Similarly, it is strange that the only illustration and reference to the artificial kidney should be twelve years old while it cannot be accepted even in the year of publication (1959) that surgical closure of ventricular septal defect "is not yet possible."

It is surprising to read that radio-strontium is advocated for blood volume studies when safer agents like radio-chromium with its relatively short half life is available and has been used in clinical investigation for five years or more. These remarks however, do not detract from the general value of the book as an introducion to a physiological approach to surgery and though one might wish that the text were more detailed in places the physical size and balance of the book would not allow this.

The preface to the text directs the volume to postgraduate students. The post-graduate students' main obsession in the physiological field is the primary

Fellowship examination where the extent of enquiry is far deeper than this book attempts to go. To the graduate working for the Fellowship however, the book would be of great help. For the undergraduate fresh to clinical surgery the approach is probably too discursive, but within a few months he should find it more useful and informative than many of the other specialized volumes which find their way into his possession.

It is a book illustrating the refreshing change which is overtaking surgery and is most welcome. There is always a leavening of basic science in the discussion of clinical problems and it is this which will attract the enquiring mind whether it be undergraduate or senior surgeon to the book which is produced with all the simplicity and style that are the hallmarks of the Livingstone Press.

ESSAYS ON THE FIRST HUNDRED YEARS OF ANAESTHESIA.

By W. STANLEY SYKES. Edinburgh: E. & S. Livingstone Ltd., 1960. 9" x 6¾", viii plus 171 pp., 39 plates, 19 illustrations. Price: 30s. (stg.).

This volume of essays cannot but interest any reader who opens its pages. It has been written in chapter form, but each chapter is a separate essay dealing with some facet of the first hundred years of anaesthesia. The word "anaesthesia" being thus spelt, it follows emphasis is on the British Isles and in particular England and Scotland.

The whole subject is left delightfully vague. In the preface, the author sets out how he intends to write his book. He proposes with 6,000 illustrations to picture "every apparatus which has ever been used in anaesthesia." Since the preface contains no fewer than 11 figures and 11 plates, the reader turns to the first chapter expecting to be overwhelmed with illustrations of ancient equipment. This is not borne out in this first volume. However, the following pages contain pictures of historical interest, many of which have been prepared by the author.

The starting point of the first hundred years is quite indefinite, for in one chapter Davy, 1799, is included. However, it is probable that 1846 and the introduction of ether anaesthesia into Great Britain is looked upon as the commencement.

The author has gone to a great deal of trouble in trying to allot priorities for various events. For example, he has traced the sailing and arrival dates of Cunard liners in 1846 in an endeavour to establish that Dr. Scott of Dumfries was the first to administer ether in Great Britain. In the same careful manner he has sifted statistics in order to show that chloroform was just as lethal in Scotland as in England. There is an interesting chapter, entitled "Curare," or "The Squire of Walton," which details Walton's expeditions to South America in 1812 and his discovery of the properties of curare.

To the present-day anaesthetist, the quarrels and stupidities of the last century should provide entertaining reading.

Further volumes of this work will be looked for with interest as they are likely to deal with some of the great names in British anaesthesia at the turn of the century.

This volume can be recommended to any reader who wishes to obtain some idea of the background to medicine as well as the development of anaesthesia in England and Scotland.

RECENT ADVANCES IN SURGERY.

Edited by SELWYN TAYLOR. Fifth Edition. London: J. & A. Churchill, 1959. 8¼" x 5¼", xiv plus 500 pp., 160 illustrations. Price: 60s. (stg.).

This stimulating picture of surgery as it is developing now is of the greatest value to surgeon, surgeon-in-training, and to the physician to show what can be offered.

In the difficulty of discerning a clear path, what could be more authoritative and judicial than "The Ischaemic Leg," truly a great joy to any teacher; what clearer and more precise than "Cross-Infection"; what more attractively presented than "Argentaffinoma and 5-Hydroxytryptamine." Throughout this excellent book there is immense help, for each chapter is the work of an authority in his field.

Two dangers appear but infrequently in the form of presentation — an enthusiast may over-play his especial view and the specialist in a limited and complex field may talk down too steeply to his less well-informed readers.

The editor has preserved a well-balanced and high presentation and altogether his choice of subject and his judgement have been really good — to him and all his contributors we are deeply indebted.

GASTRIC CYTOLOGY — PRINCIPLES, METHODS AND RESULTS.

By RANDOLPH OTTO KARL SCHADE. London: Edward Arnold & Co., 1960. 9½" x 7½", 83 pp., 85 figures. Price: 59s. 6d.

This modern classic on gastric cytology provides a very lucid and comprehensive review of the subject, based on the author's five years' study, and 3,500 examinations. Good reasons are given for the claim that gastric cytology must now be regarded as an established method of investigation.

In the first part of the book the basis of cytology in general is discussed, and there follows a description of suitable techniques for the collection of exfoliated gastric material, and the preparation and staining of smears.

The second section gives detailed descriptions of the cells which appear in gastric smears, both normally and in disease. There are included at the end of the volume numerous fine quality microphotographs.

An important section in the book is that which analyses the results obtained, and evidence is provided that an overall accuracy of 96 per cent. is possible. However, of greater interest is the observation that of the group of cancer patients studied, 10 per cent. were undiagnosed by radiology, and some of these were not even suspected clinically.

The information contained in this authoritative monograph lends much weight to the view that cytology services should now be available at our larger hospitals.

INDEX